The Impact of the Shell Questacon Science Circus Science Shows on Teachers' Classroom Practice

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Declaration

I certify that this thesis does not incorporate without acknowledgement, any material previously submitted for a degree or diploma at any university; and that to the best of my knowledge and belief, it does not contain any material previously published or written by another person except when due reference is made in the text.

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Abstract

This study evaluates the effect of the Shell Questacon Science Circus science shows on teachers' classroom practice. Data were collected through a self-administered questionnaire sent to all schools visited by the Shell Questacon Science Circus on one particular trip to New South Wales in February – March 2005.

This study also investigated whether the current practice of the science circus is applicable in Indonesia. For this part of the study, a literature review and discussion about Australian and Indonesian science teaching and learning were conducted and conditions in both countries were reviewed to justify the answer.

There is an indication that the Science Circus science shows affect teachers' classroom practice. Some respondents reported that the science shows made their teaching more creative, integrated fun and encouraged hands-on practice. Some also said that it helped them to become more confident in teaching, as well as helping them to think about science in a more practical way connected to everyday life.

The study concludes by arguing that there is also the possibility of implementing the science circus practice in Indonesia. Both countries show similarity in some aspects: a large land area, disperse population and similar conditions in science teaching and learning practice. However, it will require hard work and extensive coordination from many sectors including government and the Indonesian science centre (*PPIPTEK*).

CONTENTS

List of Figures

List of Tables

Chapter 1 Introduction

1.1 Background

The last 20 years have seen a rapid development of science centres in many parts of the world. This rapid development has been driven by the idea that a formal science education is not the only way to learn about science and can be complemented by more informal learning. Science centres contribute to informal science learning by providing first-hand science experience for the public. In Australia, Questacon, the National Science and Technology Centre, is located in Canberra and provides the Australian public with a hands-on informal science experience. Australia is a large country with a relatively small and dispersed population. To address this problem Questacon initiated the Shell Questacon Science Circus (hereon referred to as the science circus) in 1985. The science circus is a travelling version of the science centre and visits regional Australia to make science more widely accessible. Members of the science circus perform shows in schools and set up exhibitions containing up to 50 hands-on science exhibits in a central town hall, which is open to the public.

A team of two science circus members performs the science show in the schools. The performance is designed to be an entertaining display of science using familiar everyday items. The shows intend to inspire the students and instil enthusiasm in science as well as to show the relevance of science and technology in everyday life. The shows cover a variety of topics: Balance, Balloons, Bubbles, Collisions, Flight, Friction, Liquid Nitrogen, Music, Pressure, Roundabout, Shark, Slime, and Structures. A typical one-hour presentation usually consists of two shows with a short performance, called a 'busk', in between. The topics of the shows are not altered to fit any particular age group; however, the presenters do adjust the language and the content of the show to suit the audience.

1.2 Previous research

A number of studies has highlighted how interest in science has been decreasing in schools and university students around the world (Dekkers & Laeter, 2001; Osborne, 2003; Taylor, 2004). Rennie, Goodrum & Hackling (2001) have identified problems in science teaching and learning in Australia. Informal learning, however, can complement formal science learning and the nature of informal learning in a science centre environment has been well documented (Wellington, 1990; Falk & Dierking, 1992; Hein, 1998; Rennie, 1999; Falk & Dierking, 2000)

A number of evaluations of the Shell Questacon Science Circus has been done. Barbagallo (1997), Rennie & Williams (2000) and Burns (2003) produced the most comprehensive examples. Barbagallo (1997) investigated the science circus' contribution to the public understanding of science. Rennie & Williams (2000) conducted an evaluation of the educational effectiveness of the science circus program in fulfilling its objectives. Burns (2003) conducted research into the effectiveness of science shows and the science circus was one of his major case studies. These studies will be described in detail in Chapter 2.

1.3 THE PROBLEM

Science shows are one way of experiencing science. The science circus has enabled science shows to be more accessible for schools in all regions of Australia. However, no research has been performed to evaluate the value of the science shows for teachers, in particular the effect of the science shows on teaching practice.

There are no science shows in Indonesia at present, and so Indonesian students have not yet had the chance to experience science through a science show delivery. Although Indonesia does have one science centre in the capital city, Jakarta, called *Pusat Peragaan Ilmu Pengetahuan dan Teknologi* (*PPIPTEK*), the country area is very large and the population is dispersed. Like Australia, these factors limit access to the science centre. Therefore the study of the science circus in Australia would also benefit Indonesia, as it can provide an insight into the feasibility of implementing a similar program in Indonesia.

1.4 THESIS STATEMENT

This thesis describes the impact of the science circus' science shows on teachers' classroom practice, based on the teachers' own perspective. It will use evidences gathered from questionnaires filled in by teachers who watched the science shows during the science circus visit to their school. This data will be then used towards further researching the feasibility of applying the science circus model in Indonesia.

1.5 THE RESEARCH QUESTIONS

- Does the science show performed by the science circus in schools affect teachers' classroom practice in any aspect?
- Is the science circus a feasible model for Indonesia?

1.6 METHOD

A self-administered questionnaire was chosen as a method to answer question 1. The questionnaire was sent to all schools visited by the science circus on a particular trip to the northern New South Wales area in February – March 2005.

This study also investigated whether the current practice of the science circus is applicable in Indonesia. For this part of study, a literature review and discussion about Australian and Indonesian science teaching and learning were conducted and conditions in both countries were reviewed to justify the answer.

1.7 SIGNIFICANCE OF THE STUDY

The result of this study will provide Questacon with an evaluation and insight into the impact that the science circus visits to schools had on the teachers' classroom practice. The evaluation will also provide suggestions of how to improve the science circus programs, which ultimately will benefit the schools as well. The results will also provide useful information to consider the feasibility of the science circus model for Indonesia.

1.8 LIMITATION OF THE STUDY

This research only investigates one particular science circus trip, from 26 February – 24 March 2005 to northern New South Wales. This was the first trip for the science circus members who were all just starting the Graduate Diploma program in science communication at the Australian National University. I therefore suggest that this particular trip might not represent their best performance of the year. The schools visited on this trip may not be representative of all Australian schools because only a specific area of New South Wales was visited. The analysis of the impact of science shows on the classroom practices of teachers is based only on the teachers' own perspective. However, this study can provide suggestions of how to improve the science circus program from the teachers' point of view and contribute to determining the impact of the science shows on teaching practice.

1.9 Overview of the study

I present issues relevant to this study in the literature review in Chapter 2. In Chapter 3, I discuss the research methodology and the method used for this research. The results gathered from the questionnaire are presented in Chapter 4. I answer the research questions through discussion and conclude the study and offer some suggestions for further research in Chapter 5.

Chapter 2 Literature Review

2.1 THE IMPORTANCE OF SCIENCE

Many nations now consider a background in science as important knowledge to have. Science and technology are acknowledged as powerful instruments of socio-economic development for nations (Tan & Subraniam, 2003; Iaccarino, 2004). It is even implied that the nation's welfare is proportional to its science and technology, so the more literate a nation is in science and technology the better its economic life. Iaccarino (2001) gave the example of Western Europe. This region is considered to be advanced in science and technology; one indicator he used was the fact that 50% of Nobel laureates in natural sciences come from Western Europe. He stated that their science and technology advances have made them one of the strongest economic powers in the world, with GNP up to US$8,900 billion.

Maund (2001) provided an alternative example. Colonialisation in the Caribbean prevented the country from gaining knowledge in science and as a consequence their economy did not expand. After its political independence the Caribbean attained a better understanding of the relationship between socio-economic development and scientific competence. Finally they realised the need to integrate science and technology into their culture and social attitudes in order to be able to survive and prosper in an age of liberalization and industrial competitiveness.

Science also benefits individuals because it helps us to understand everyday life phenomena and contributes to the information we use to make personal decisions. Therefore the public understanding of science is desirable (Durant, Evans, and Thomas, 1989; Sjøberg, 2001).

The designers of the ROSE (Relevance of Science Education) project (2001) rationalise their study on public understanding of science and technology, as follows:

> "A broad public understanding of S&T is crucial for national economical development and to the life, independence and autonomy of each individual."

Rennie *et al.* (2001 p.455) use a different term for 'public understanding of science'; instead they use 'scientific literacy':

> "Fundamental to the research was the belief that scientific literacy is a high priority for all citizens, helping them to be interested in, and understand the world around them, to be sceptical and questioning of claims made by others about scientific matters, to be able to identify questions, investigate and draw evidence-based conclusions, and to make informed decisions about the environment and their own health and well-being."

Australia also recognises the importance of science and technology and acknowledges that science and technology are an integral part of social development and economic growth (Australian Government, 2003-2004; Australian Government, 2004-2005) as well as benefiting the daily lives of Australian residents (Australian Government, 2004).

Indonesia in its *Undang-undang Dasar 1945* (The 1945 Constitution of the Republic of Indonesia) acknowledges the importance of science and technology. It is stated in article 31.5 that the government shall advance science and technology with the highest respect for religious values and national unity for the advancement of civilization and the prosperity of humankind (*Undang-undang Dasar 1945*, last amendment in 2002).

Unfortunately, in contrast with an increasing awareness at government level of the importance of science and technology, interest in studying science subjects at school has been decreasing in many countries around the world.

2.2 STUDENTS' INTEREST IN SCIENCE

Many reports indicate that interest in studying science has been decreasing. This has happened, for example, in England and Wales (Osborne, 2003; Royal Society London, 2004; BBC news, 2004; BBC news, 2005), in France (the Scientist, 2004), in Australia (Dekkers & Laeter 2001; Capp, 2005), and in New Zealand (Taylor, 2003). A similar trend is also occurring in Asian countries, such as Korea and Indonesia (The Korea Herald, 2003; *Departemen Pendidikan Nasional Indonesia*, 2001-2004).

Research has been conducted in an attempt to reveal the reason for this declining interest in science. This research has led to the evaluation of formal science education in schools. A thorough international research project called ROSE – the Relevance of Science Education – was launched in Sweden in 2001. This project aims to capture aspects of interest in science education through a questionnaire that asks 15–years-olds about their attitudes to science and technology. Students from many countries have already participated in this study. The data collection is ongoing. Sjøberg and Schreiner (2005) presented preliminary results from the ROSE project in their keynote presentation at the EU's Science and Society Forum 2005, in Brussels, 8-11 March 2005. Early results show that children in all countries strongly agree that science and technology are important for society and are needed for development. However, in most countries there is an indication that children are sceptical of what scientists have to say and children also doubt that scientists are neutral and objective. The results also show that science is less popular than other subjects in many industrialised countries and that in many countries girls seem to dislike school science. Finally, the study revealed that few children (girls in particular) dream of becoming a scientist in industrialised countries.

Rennie *et al.* (2001) conducted research in science teaching and learning in Australian schools. Many students experience disappointment because "the science they are taught is neither relevant nor engaging and does not connect with their interests and experiences" (p.455). This is especially true at high school level. This situation is the source of students' disappointment and when science is no longer compulsory, students run away from it. The decreasing number of students who choose science subjects at school was confirmed by Dekkers & Laeter (2001).

Osborne (2003) believes that the decreasing interest in science study requires investigation focused on students' attitudes toward science. Osborne reviewed the major literature about attitudes to science. He also identified factors that influence students' attitudes towards science such as gender, teachers, curricula, and cultural factors. Finally, he suggested that it is important to conduct research to identify aspects of science teaching that would make science more engaging for students.

In this study, I will look closely at how science is taught in Australia and Indonesia. Therefore it is necessary to have background knowledge about the education systems in both countries.

2.3 AUSTRALIAN AND INDONESIAN EDUCATION SYSTEM

This section compares the education systems in Australia and Indonesia as well as describing science teaching and learning in both countries. Similarities between problems in Australia and Indonesia are also identified in this section.

2.3.1 Australian education system

In Australia education is compulsory from year 1 (the age of six) to year 10 (the age of 15). Years 1 – 6 or 7, which depend on the state or territory, are considered to be primary schooling. Lower secondary schooling starts in year 7 or 8 (depending on the state or territory) and ends at year 10. Years 11 and 12 are classified as upper secondary level. The education is compulsory until the age of 15 years. Usually most students will not leave school until they have completed year 10 and many of them continue until they have completed year 12.

Each state and territory government is responsible for their own curriculum; it is not the responsibility of the federal government. Therefore, the content of curricula differs from one state and territory to another. In this thesis, I will use the New South Wales science curriculum for evaluation as the majority of participants in this study come from the New South Wales area.

2.3.2 Science teaching and learning in Australia

At the primary level, science is compulsory as it is one of the core subjects included in the eight key learning areas (Department of Immigration and Multicultural and Indigenous Affairs – DIMIA, 2005; Ministerial Council on Education, Employment, Training and Youth Affairs – MCEETYA, 2001). The areas covered by the science and technology curriculum for the NSW primary levels are: built environment, information and communication, living things, physical phenomena, produce and services, and the earth and its surroundings. The syllabus for K-6 in NSW aims to develop the competency, confidence, and responsibility of students through experiencing science and technology within a broad framework (Board of Studies New South Wales, 1993).

For the primary levels, the class teacher is responsible for teaching all subjects and so does not specialise in just one subject. In this situation, therefore, science is usually taught and integrated with other subjects and so it is hard to measure the time spent on science teaching (Rennie, 2001). Rennie found that in Australia, science is taught for an average of 59 minutes per week. This result is supported by the New South Wales Board of Studies evaluation in 1996 for K-6, which shows a range of 60-120 minutes per week spent on teaching science and technology, with the majority tending towards the lower end of the range (Board of Studies New South Wales, 1996).

Science is also compulsory at the lower secondary level. At this level the study of science aims to build up students' scientific knowledge and understanding, skills, values and attitudes within broad areas of science that include: physics, chemistry, biology and earth science. Students are also expected to be able to apply their scientific knowledge and skills to their understanding of everyday life (Board of Studies New South Wales, 1998). At this level teachers specialise in specific subjects and will teach only those subjects. In secondary school, science subjects are taught for, on average, 200 minutes per week. This varies from 150-240 minutes per week from state to state (Rennie *et al.*, 2001).

Science is optional for the upper secondary level (DIMIA, 2005). The science courses offered for these years include: physics, chemistry, biology, earth and environmental science and an integrated science course. The students may choose one or more courses in specific science areas, an integrated science course or decide not to study any science at all (Board of Studies NSW, 1998).

Rennie *et al.* (2001) conducted a national study in science teaching and learning in Australia for the Department of Employment, Training and Youth Affairs of the Australian Commonwealth Government. This was a complex study on a large scale, involving an extensive literature review about science education, focus groups and telephone surveys of teachers, a student survey by questionnaire, submissions from interested stakeholders in the community, and case studies of best practice. The study described the actual and ideal picture of science teaching and learning in Australia and suggestions on how to close the gaps.

Regarding science teaching and learning, Rennie's study revealed that primary level students were more satisfied with the science that they were taught at school because it was taught in a more 'student-centred' approach than it was at secondary level. Science subjects at secondary level are predominantly content based and are taught in a 'teacher-centred' way. Rennie found that 61% of the students claimed that they copy notes from the teacher nearly every lesson. The teacher interviews confirmed that at secondary level, a 'chalk and talk' and practical approach is quite common.

From group discussions with teachers, Rennie found that science subjects at the secondary level have a heavy content component. Teachers only have a very limited time to cover this content in order to prepare the students for examination. The traditional assessment practice through tests and examinations leaves teachers with little leeway to use other methods.

Rennie's interviews with both primary and secondary school teachers revealed that teachers felt there was not enough time to teach science or to cover the whole science content in the time available. Students, who cannot see the relevance of the science subjects to their needs, feel overburdened with this content-based science syllabus. Finally, the negative experiences of students in science classes in the lower secondary years result in the students choosing not to take these 'difficult' subjects in the upper secondary level when studying science is not compulsory. Not surprisingly Dekkers & De Laeter (2001) found a trend of declining student numbers in Australian school science education. The data show that on average students enrolled in 1.3 science subjects in 1988 and within just a decade this number dropped to an average of 0.86 in 1998.

Rennie also interviewed teachers and asked their opinions about factors limiting the quality of school science. Lack of resources was the most frequently mentioned factor by both primary and secondary school teachers. Both also mentioned the inadequate time to prepare classes and time to teach science, lack of background knowledge to teach science, lack of professional development in science and an overloaded curriculum. In addition, the secondary teachers feel that the class sizes are too large and mentioned student related factors, such as the poor behaviour of students.

2.3.3 Indonesian education system

In Indonesia, *Undang-undang Republik Indonesia nomor 20 tahun 2003 tentang Sistem Pendidikan Nasional* [Law of the Republic of Indonesia, number 20, year 2003 on the National Education System] states that formal education begins in primary school at seven years old. It also explains in article 17.2 that primary school consists of two levels: *Sekolah Dasar* or *SD* for short (elementary school) and *Sekolah Menengah Pertama* or *SMP* for short (junior secondary school). *Sekolah Dasar* (elementary school) begins in year 1 (at the age of 7) and continues to year 6 (at the age of 12). After that there are three levels of *Sekolah Menengah Pertama* (lower secondary school): years 1 – 3 for the ages of 13 – 15. This level is equivalent to year 7 – 9 in Australia (*Peraturan Pemerintah* – Indonesian Government Rules, article 6.4, 2004). Like Australia, education in Indonesia is compulsory for all Indonesian children between the ages of 7 to 15 (*Undang-undang Republik Indonesia nomor 20 tahun 2003 tentang Sistem Pendidikan Nasional*, article 6.1, 2003).

The next level of formal education is the senior secondary school. Students may choose between general *Sekolah Menengah Atas* or *SMA* for short (general upper secondary school) or *Sekolah Menengah Keterampilan* or *SMK* for short (vocational secondary school) (*Undang-undang Republik Indonesia nomor 20 tahun 2003 tentang Sistem Pendidikan Nasional*, article 18.2, 2003). Senior secondary school (either *SMA* or *SMK*) consists of three levels: years 1-3, which are equivalent to years 10-12 in Australia.

The Indonesian government establishes the basic structure of the curriculum. The curriculum is developed in accordance with relevance to each education level and school committee. City or district governments coordinate and supervise the elementary level and the provincial government does the same thing for the secondary (*Undang-undang Republik Indonesia nomor 20 tahun 2003 tentang Sistem Pendidikan Nasional*, article 38, 2003). Curriculum development is done in accordance with *standar nasional pendidikan* (national standard for education). The curriculum is developed with variations to suit the education level, local potential and students (*Undang-undang Republik Indonesia nomor 20 tahun 2003 tentang*

Sistem Pendidikan Nasional, article 36, 2003). The decentralised curriculum is the government's initiative to make education more reflective of local needs.

A minimum syllabus for science and other subjects in primary and secondary level is set by the Ministry and is reviewed every 5 years (*Peraturan Pemerintah*, article 15.15, article 35.14 and article 80.15, 2004). Schools can, however, add new ideas related to the newest science and technology developments to the syllabus on their own initiative (*Peraturan Pemerintah*, article 15.16, article 35.16, and article 80.16, 2004).

All subjects in all school levels including science and technology subjects must be presented in an interactive, inspiring, and fun manner as well as being challenging and encouraging creativity and independence (*Peraturan Pemerintah*, article 15.19, article 35.19, and article 80.19, 2004).

2.3.4 Indonesian science teaching and learning

Science is compulsory for primary and secondary schooling in Indonesia, together with many other studies, including: religious study, citizenship study, language, mathematics, social, physical and health, vocational, and local content (*Undang-undang Republik Indonesia nomor 20 tahun 2003 tentang Sistem Pendidikan Nasional,* article 37, 2003).

In *Sekolah Dasar* (elementary school), science and technology subjects aim to familiarise students with the subjects and encourage an appreciation of science and technology as well as to construct critical, creative and independent scientific thinking (*Peraturan Pemerintah*, article 15.8, 2004). Similar to Australia, science in *Sekolah Dasar* (elementary school) is taught by the class teacher, not by a specialised science teacher (*Peraturan Pemerintah*, article 20, 2004).

Science in *Sekolah Menengah Pertama* (lower secondary school) level is also compulsory. However, the science subject is no longer as general as in *Sekolah Dasar* level. It is split into specialised physics and biology subjects. The subjects are taught by teachers who specialise in these specific subjects (*Peraturan Pemerintah*, article 41.1, 2004). The science and technology subjects aim to provide basic competency in science and technology as well as to construct critical, creative and independent scientific thinking (*Peraturan Pemerintah*, article 35.7, 2004).

Science in *Sekolah Menengah Atas* (upper secondary school) consists of physics, biology and chemistry subjects. The science subjects aim to instruct in applied science and technology, build students' competency, capability and independence (*Peraturan Pemerintah*, article 80.7, 2004). Again, the teachers for science subjects are specialised at this level. (*Peraturan Pemerintah*, article 86.1, 2004).

In the first and second year of *Sekolah Menengah Atas* (upper secondary school), the science subjects (physics, biology and chemistry) are compulsory for all students. In the third year, students have to choose one of three streams available: science, social science or language. In each stream the students would receive more specialised instruction in a narrower range of subjects.

The science stream focuses more on science studies such as physics, chemistry, biology and mathematics. The social science stream focuses more on social studies such as economics, sociology, forms of government and anthropology. The language stream focuses on Indonesian language and literature, English, additional foreign language and cultural history. Many schools only offer the science and social streams and not the language stream because Indonesia does not have enough teachers who have mastered a foreign language.

Data from the *Departemen Pendidikan Nasional Indonesia* (Indonesian department of education) in Table 1 show that there are always more students who choose the social stream than the science stream. Data from 2000 – 2004 show that on average, 38% of students choose the science stream and 58% of students choose the social science stream every year. Table 1 presents the numbers.

Table 1: Number of students based on their stream choice in 2000-2004

Year	Science		Social		Language		Total
	No.	%	No.	%	No.	%	
2000/2001	358,453	37.97	555,651	58.65	31,880	3.38	943,984
2001/2002	367,250	38.15	562,453	58.43	32,903	3.42	962,606
2002/2003	375,519	38.22	576,125	58.64	30,892	3.14	982,536
2003/2004	377,696	37,43	595,258	58,99	36,149	3.58	1,009,103

Similar numbers are observed in data regarding the numbers of students graduating from each stream (*Departemen pendidikan dan kebudayaan*, 2000-2004). Data from 2000-2004 show that out of a total of nearly 900,000 students 37-38% graduated from the science stream and 59% graduated from the social stream and only about 3% graduated from the language stream. The details can be seen in Table 2.

Table 2: Number of students graduating from each stream in 2000-2004

Year	Science		Social		Language		Total
	No.	%	No.	%	No.	%	
2000/2001	335,053	37.62	526,226	59.09	29,233	3.28	890,512
2001/2002	343,058	37.90	532,560	58.84	29,441	3.25	905,059
2002/2003	355,985	38.07	547,677	58.57	31,465	3.36	935,127
2003/2004	365,979	37.99	565,979	58.66	32,302	3.35	963,410

As in Australia, it is only possible to establish the number of students who are interested in studying science when it is no longer a compulsory subject. The numbers can be obtained from the final year of *Sekolah Menengah Atas* (equivalent to year 12 in Australia).

Students in *Sekolah Menengah Pertama* and *Sekolah Menengah Atas* often struggle with their science subjects due to the nature of teaching. A teacher-centred teaching style with a 'chalk and talk' method is common practice in Indonesia. Teachers usually teach in front of the class, teaching concepts, formula, facts and figures. Students listen and take notes (Prayekti, 2002). Teaching is based on content and mainly focuses on formulae and facts. Students have to memorise and use the formulae in complex calculations, remembering figures and facts to be able to succeed in the tests used to assess their progress. In practice, Indonesia still lacks experience in science and no effort is made to link science to situations in everyday life (Taufik, 2004). Science teaching practice in Indonesia tends to place a lot of emphasis on cognitive aspects, which I will discuss in more detail later on in this chapter (Sholahuddin, 2001). The total effect of all these phenomena is to make science subjects intimidating for the students. In addition to this, students perceive science subjects as being difficult and therefore to be avoided (Day, 2003).

2.3.5 Similarities between problems in Australia and Indonesia

It is clear that Australia and Indonesia have similar problems in science teaching and learning. Usually, science subjects are still taught with an emphasis on content, with a teacher-centred method. Although both countries seems to have good content and intention in the curriculum, and in the countries' education policy (for example, statements such as "aim to show the relevancy of science to everyday lives", or "subjects should be taught in an interesting manner to draw students' interest"), real practice does not reflect these goals. The methods of evaluation used (tests and exams) usually force teachers to stick to more traditional teaching methods. The result of this is that students cannot see the relevance of science to their everyday lives and so tend to avoid the subjects when they are no longer compulsory.

2.4 Ideal science teaching and learning

In Australia, Rennie (2001) developed an ideal picture of quality teaching and learning of science in Australia, which can be grouped into several themes. The themes covered are the science curriculum, the teaching-learning environment in science, teaching as a profession, resources for teaching and learning science, and the value of science education. A brief explanation for each theme is provided below.

First, the science curriculum. The science curriculum needs to be relevant to students' needs and interests, and to recognise the importance of understanding science through inquiry. It also promotes assessments with focus on the learning outcomes.

Second, teaching-learning environment in science. The teaching-learning environment should be characterised by enjoyment, satisfaction, ownership of and engagement in learning.

Third, teaching as a profession. Teachers need on-going support including professional development.

Fourth, resources for teaching and learning science. The class needs to have excellent resources to support teaching and learning practice, which should also be supported by ideal class sizes.

Fifth, the value of science education. Science has a high priority in the school curriculum, it is valued by the community, and science teaching is acknowledged as an important contribution to the nation's economic and social well being.

In Indonesia there was only a limited number of schools that were willing to try a different approach in science teaching and learning. Prayekti (2002) documented one such case where a Science Technology Society approach was implemented in a primary school in Indonesia. The Science Technology Society approach considers science and technology as a part of everyday life and recognises its roles in society, not only focusing on the science content. The results were very positive, student creativity was improved and the students were more able to recognise science in their everyday life. The Science Technology Society approach is also consistent with the constructivist method of teaching that will be mentioned later on in this chapter (Schulte, 1996).

Indonesia conducted a National Science Olympiad from 24-28 August 2004. In a speech at this event, Indonesian academic, Professor Gede Raka, commented on the need to change current science teaching practice in Indonesia. Raka claimed that Indonesia needs to address six factors including point of view, learning environment, learning process, approach, content, as well as the roles of teachers and principles (Taufik, 2004).

An article in the Indonesian newspaper, *Pikiran Rakyat*, called for the recognition of the 'multiple intelligence' approach in teaching and learning practice. The author believes that the current approach does not optimise the students' potential (Riekasapti, 2004).

2.5 INNOVATIVE LEARNING THEORIES

Some new concepts in learning, such as multiple intelligence and constructivism are increasingly becoming more popular. A brief explanation of each theory is provided below as I recognise their potential to improve teaching and learning practice in general.

Gardner (1993) was the founder of multiple intelligence theory. Gardner believes that people have different talents and therefore they learn differently. Gardner proposes that there are seven types of intelligences. Verbal-linguistic intelligence types learn best through words. Logical-mathematical intelligence types learn best through scientific thinking. Visual-spatial intelligence types learn best from spatial processing by drawing mental pictures in their minds. Body-kinesthetic intelligence types have good control of body movement and learn from doing something with their bodies. Musical intelligence types learn best through music, rhythm or melody. Intrapersonal intelligence types learn best by doing it themselves. Interpersonal intelligence types learn best through social interactions and working with others.

Many schools only emphasise verbal, logical, and intrapersonal intelligence (Gardner, 1993). The multiple intelligence theory encourages recognition of other forms of intelligence. If curricula were designed with regard to the needs of all types of intelligence, it would help the students to maximise their learning potential.

Constructivism is a philosophy of learning, which believes that people reflect on their own experiences to construct their own individual understanding (Schulte, 1996). Kuhn and Hand (1995) claimed that learning is not about teachers providing students with materials and information to be copied down for recall at a later time, or about teachers transferring knowledge to the students. Constructivist learning is about individuals constructing their own knowledge. Constructivist learning focuses on the learner; it is a 'student-centred' approach. The student role is an active one, not the traditional passive, note-taking role. Vance and Miller (1995) explain that the function of a teacher in a constructivist class is as a 'facilitator of knowledge' as well as a 'classroom manager'. The teacher needs to provide a preliminary motivation and a way of collecting first thoughts and then they should provide activities or questions intended to begin the thinking process.

Both theories seem to provide potential methods to improve teaching and learning practice, however, I am aware that the applications of both theories are not easy. Many things would need to be adjusted. This requires extensive coordination from government, schools, teachers, parents and students.

2.6 INFORMAL LEARNING

In the previous section describing formal science learning, in particular in Australia and in Indonesia, I highlighted some common problems as well as providing an ideal picture of science teaching and learning practice. This section discusses informal learning and its role in science learning. In efforts to improve formal science learning, informal learning has emerged as an approach that can provide support to formal science learning.

Before we can understand how informal learning supports formal learning it is first necessary to understand the principles of informal learning itself. Hein (1998 p.7) defines informal learning as a 'description of settings' without the existence of a formal curriculum. The informal learning setting can be varied, from science centres and museums to natural history museums, botanical gardens, zoos and historic homes (Packer & Ballantyne 2002; Falk & Dierking, 1992). Media such as newspapers, magazines, websites, radio and television can also be classified as informal learning tools.

Falk & Dierking (2000) prefer to use the term 'free-choice' instead of 'informal'. Free-choice learning can occur in museums, whilst watching television, reading a newspaper or even when browsing the Internet. They argue that much of what people know is constructed through a free-choice learning experience.

2.7 THE ROLES OF SCIENCE CENTRES

The science centre can be considered to be an ideal atmosphere for informal learning (Griffin & Symington, 1997; The parliamentary office of science and technology, 2000). Interactive science centres accommodate the human need to try and explore by providing interactive exhibits or activities for its visitors (Gore, 2001). For students, experience in science centres can contribute in some ways to their formal science learning in schools or at least may raise an interest in science. For adult visitors it is hoped that their visit to science centres will increase their awareness of science and technology.

Historically, science centres are considered to be second generation or modernised museums. The word 'museum' originally stems from the 'Muse', the Greek legendary character who is linked to human inspiration. It is derived from the French verb '*muser*' which was adopted by the English language as 'muse' meaning to think reflectively. Museums indeed function as places to cultivate human understanding and progress. This first generation of museums contain many collections of artefacts, which are placed in displays with written explanations of the histories behind the items (Koster, 2000).

The second generation museum was born in the late sixties. A new concept replaced the old-fashioned artefacts with interactive exhibits or, as they are more popularly referred to, with 'hands-on' exhibits. These interactive exhibits involve visitors in doing something with the exhibit and this is what makes the experience more appealing. The second generation museum is now more popularly known as the science centre or is sometimes called a science and technology centre, or a science museum. (Koster, 2000).

Frank Oppenheimer established the first science centre, the Exploratorium, in San Fransisco in 1969. The opening of the Exploratorium can be considered to be the initiation of science centre development. The huge success of the Exploratorium led to science centres becoming more popular and more science centres were built around the world. The USA, for example, has grown fast with more than 200 science centres already built by the year 2000 (Koster, 2000). Science centres have become one of the more powerful informal learning tools, and have been recognised for their efforts to portray science in a 'user-friendly' way.

Delacote (2003 p. 375) wrote about Oppenheimer's aim in developing the Exploratorium:

> "Oppenheimer's idea was to create a place dedicated to research and development – a sort of laboratory of learning – open to the public and focusing on hands-on exploration of the physical and natural world."

Nowadays we still share Oppenheimer's passion about science centres. The Association of Science – Technology Centres (ASTC) states that science centres connect people with science, encourage curiosity and provide firsthand science experience. It is a place for all kinds of people to become familiar with science (Nursal, 2003) and facilitate free-choice learning (Dierking, Luke & Buchner, 2003). Science centres provide informal learning opportunities as visitors interact with hands on activities and gain experience from them

(Taylor, 2003). The interactive exhibits and activities accommodate the human need to try and explore (Gore, 2001).

There are two terms that are frequently used in the context of science centres: 'interactive' and 'hands-on'. It is generally accepted that both terms have the same meaning, however Gore (2001 p.219) argues that they actually have different meanings:

> "The term 'hands on' is commonly used to describe the interactive devices that are used by visitors. 'Interactive', however, is better because the activity in which the visitors are engaged does not always call for the use of the hands. Frequently one or more of the other senses are brought into use."

In this study, I consider the terms 'interactive' and 'hands-on' to have different meanings.

One of the issues with science centres is the difficulty in measuring what visitors learn from their visits to a science centre. It has always been difficult to measure learning let alone describe and explain the learning itself. Learning is very individual (Kelly, 2002), it is a process as well as a product and therefore challenging and complex to understand (Falk & Dierking, 2000). It is a slow process, involving incremental growth of existing ideas and information (Falk & Dierking, 1992), new ways of thinking come from experience and the change is internal (Woolfolk, 1987 in Rennie, 1999). Learning is complex and to some degree is indescribable (Kelly, 2002).

Wellington (1990) and Falk & Dierking (1992) quoted Benjamin Bloom's 'taxonomy of educational objectives' which described three important aspects of learning: cognitive (facts and concepts), affective (attitudes, beliefs, feelings) and psychomotor (body coordination). Traditionally, cognitive is often the focus of learning in schools while affective and psychomotor aspects have not been involved as much.

Wellington (1990) argues that interactive science centres serve an educational function as they contribute to the cognitive, affective, and psychomotor domains of learning. Wellington defines the cognitive area as 'knowledge that, knowledge how, and knowledge why'. He found that hands-on science centres contribute especially in the 'knowledge that' area directly and by 'sowing seeds' and leaving memories that might lead to understanding.

We have discussed formal science education and the roles of science centres in informal learning in the previous sections. Interestingly, Falk & Dierking (1992 p.99) argue that learning cannot be separated into formal and informal categories.

> "Learning is learning…Learning can occur in classrooms, museums, homes, and shopping malls. The content and structure of the learning are determined by the three contexts [cognitive, affective and psychomotor] described above. The terms 'formal' and 'informal' have little predictive value in relation to learning."

Gore (2001) argues strongly that it is wrong to imply that science centres are engaged in teaching scientific facts, although he agrees that informal learning does take place. In Gore's opinion (p.232) science centres "are not, and were never intended to be formal science teaching institutions". Gore also believes that science centres must be both relevant and entertaining.

To provide real pictures of science centres, the next section will discuss the National Science and Technology Centre in Australia, Questacon, and the science centre in Indonesia, *PPIPTEK*.

2.7.1 Questacon – The National Science and Technology Centre

There are a number of science centres in Australia of which Questacon is the largest. Questacon was the first science centre to be opened in Australia. Questacon aims "to be a national leader in engaging people in science and technology" (Australian Government, 2003-2004 p.5), especially for young Australians, helping to develop positive attitudes towards science and technology. Questacon is also committed to making science fun and relevant to everyone (Australian Government, 2003-2004).

Questacon has seven galleries with over 200 exhibits, which are designed to be fun and interactive as well as to communicate science. Each gallery has a theme that reflects the science of everyday life. For example, 'Strike a Chord – the science of music' was the latest exhibition theme Questacon opened in 2005. All exhibits are designed to be hands-on and interactive. Questacon also runs science shows for its visitors. There are many different shows from puppet shows for pre-school children to scientific talks for more mature audiences.

Questacon has various outreach programs in order to bring science to communities outside Canberra and make it more accessible for everyone. Their outreach programs include the Shell Questacon Science Circus, Questacon Science Squad, Questacon Smart Moves, Questacon Indigenous Outreach, and Questacon Maths Squads. Questacon reported that more than 275,000 visitors visited the outreach programs in 2003-2004 (Australian Government, 2003-2004).

The idea for the development of Questacon was begun by an informal conversation about science centres between two best friends, Dr Michael Gore and Dr Chris Bryant in a beach house on the south coast of New South Wales. The result of that informal conversation was the establishment of Questacon in 1980. It was the first in the southern hemisphere and one of the first in the world.

In the beginning Questacon was located in an unused school in Ainslie, a suburb of Canberra. Some simple science exhibits were available and explainers (volunteer undergraduate science students) were available to assist the students who came for a booked session. Due to limited resources, for the first few months Questacon only received bookings from schools and did not open to the public.

Questacon opened to the public a year later and soon became very popular as a tourist destination. As the number of visitors grew it was clear that the venue could not accommodate the crowd. Mike Gore, the founder of Questacon, created science show sessions to take some visitors away from the exhibition floor. The science shows gave the visitors an opportunity to have a rest as well as enjoying the show. Since then, the science show has played a significant role as one of Questacon's major attractions. Science shows formed an important part of the Shell Questacon Science Circus that was established in 1985. These science shows are the focus of this study. The details about the science shows and the science circus will be presented in a separate section 2.9.3.1.

In the early days Questacon operated under the wing of the Australian National University. It changed later on when The Australian Bicentennial Authority was formed in 1982 with the duty of planning the celebration of 200 years of white settlement in 1988. The Japanese nation had offered to give ten million dollars as a birthday gift. The money was used as the capital with which to build a new building for Questacon which was completed in September 1988. The Prime Minister, Bob Hawke, formally opened Questacon – the National Science and Technology Centre on the 23 November 1988 (Gore, 2001). Dr Michael Gore was appointed as the founding director of Questacon.

Questacon has accomplished many things since its opening. In 2003-2004, Questacon reported having more than 1.3 million visitors to all of their programs.

2.7.2 Science centre in Indonesia: *PPIPTEK*

Indonesia has only one science centre called *Pusat Peragaan Ilmu Pengetahuan dan Teknologi* or *PPIPTEK* for short. This centre is located in the capital city, Jakarta.

PPIPTEK is an informal institution (outside schools), which tries to introduce science and technology to people of all ages. The entertainment factor is integrated through interesting interactive exhibits. It is expected that the interaction between visitors and the exhibits will drive an interest in the 'What, Why and How' of science and the way science is used for human benefit.

PPIPTEK's vision is to educate Indonesian citizens and cultivate an understanding of science and technology. The mission is to fertilise curiosity and enjoyment in observing natural phenomena, and learning the science and technology behind it all. It is hoped that this will build a love for science which may affect the career decisions of students in the future.

PPIPTEK was established on 20 April 1991 and was located in a small building in *Taman Mini Indonesia Indah* (Indonesian Miniature Park), a theme park in Jakarta. In November 2001, *PPIPTEK* moved to a new bigger building that was especially designed for public use. *PPIPTEK* was formally opened by President Suharto on 10 November 2001 and has remained open to the public since then.

There are about 250 exhibits in *PPIPTEK* which can be categorised into eight clusters: Basic Education, Transportation, Sea Transportation, Air Transportation, Environment, Energy and Resources, Telecommunications and the Little Researcher area.

The number of visitors was recorded from 1996 onwards. The details are available in Table 3 below.

Table 3: Visitors to *PPIPTEK*

Year	Public visitors	Student visitors	Total visitors
1996	38,340	149,281	187,621
1997	87,005	203,729	290,734
1998	19,367	61,159	80,526
1999	56,221	118,114	174,335
2000	113,972	250,028	364,000
2001	93,987	198,112	292,099
2002	87,191	160,108	247,299
2003	66,934	215,832	282,766

These numbers show a steady flow in visitors to the centre. On the average, about 250,000 visitors come every year. 1998 showed a decrease in numbers when only about 80,000 visitors came to *PPIPTEK*. This phenomenon happened because of the economic crisis in 1997, which continued until 1998. In addition there was a problem with electricity supply in January and February 1998 so the centre only operated for some days during those two months (Personal Communication).

2.8 Travelling science centres

Access to science centres can be a major problem for some people. Travelling distance and time to travel may become impediments that reduce the opportunity to visit the science centre. Some science centres understand these problems and design outreach programs. These programs travel to visit other places, providing wider opportunities for everyone to experience the science centre.

There are a number of science centres with travelling programs: the New Zealand science centre with its Science Technology Roadshow, Scitech Discovery Centre (Perth, Australia) with its Scitech Roadshow, Questacon – The National Science and Technology Centre (Canberra, Australia) with its Shell Questacon Science Circus, Questacon Smart Moves, Questacon Science Squad and Questacon Maths Squads. These are only some of the science centres in Australia and New Zealand with the initiative and commitment to reach more people by travelling around the country. Many other providers that are not science centre-based conduct similar outreach programs. Some examples in Australia are: CSIRO Science Education Centre with its Labs on Legs, Queensland University of Technology with its QUT Innovation train, The University of Melbourne with its Muppets – the magic show from the school of physics, and some programs conducted by the Mineral Council, museums, zoos, and other similar institutions (Garnett, 2003).

In this study, I focus my research on the Shell Questacon Science Circus conducted by Questacon, the National Science and Technology Centre based in Canberra, Australia.

2.9 THE SHELL QUESTACON SCIENCE CIRCUS

This section discusses the Shell Questacon Science Circus, from its history to its current operation.

2.9.1 History

The first idea of the science circus was developed when Mike Gore, the founder of Questacon, received a request from Goulburn in May 1985 to come and perform there. Gore and some volunteer explainers loaded 20 interactive exhibits and 15 props for science shows in an old furniture van and headed to Goulburn (Personal Communication). After that time, Gore decided that Questacon would continue to make short weekend visits to towns within 100 kilometres of Canberra. That was how the science circus emerged.

It is interesting to note how Gore deliberately used the term 'circus'. The Concise Oxford English online (2004) dictionary defines "circus" (Noun) as:

> "A travelling company of acrobats, clowns, and other entertainers which gives performances typically in a large tent" or "*(informal)* a scene of lively activity."

This term used in the context of the Questacon science circus provides an idea of the nature of the operation. They travel, bringing all necessary equipment, to a certain place and perform in that place. When the performance finishes they pack everything and go to another place. However, unlike the ordinary circus, it does not involve any animals or clowns. It is more like the informal definition of circus above, 'a scene of lively activity'. The performers visit a place, bring their interactive science exhibits and provide lively activities, pack up, travel to another place and do the same thing again.

Shell Australia began to support the science circus financially in 1988. Since that time, the 'Shell Questacon Science Circus' has been the official brand name.

Noticing how the young volunteers developed themselves as performers in the science shows, Gore, together with Professor Chris Bryant (at that time Dean of Science at the ANU), set up a formal program to build on the situation. A Graduate Certificate program was offered by the Australian National University in 1987 and was upgraded to a Graduate Diploma program in 1992 (Stocklmayer, 2003).

It is a one-year program which combines a practical component, when touring in the science circus, and a coursework component. The goal was 'to produce knowledgeable and effective science communicators' (Bryant, 2001 p.250). This program is very prestigious and competitive because a full scholarship is provided for 15 selected highly qualified students each year.

2.9.2 Booking process

The science circus tour needs very careful thought and planning. Questacon employs a booking officer to arrange the tours. It is necessary to plan a tour at least one year in advance. In September every year, the science circus booking officer sends out an 'Advance Notice'. This notice is sent to schools all over Australia in areas that the science circus plans to visit in the following year. The Government District Offices and Catholic Dioceses help to distribute this notice by their usual communication channels (mail, fax or email). Other independent schools that are not covered receive direct mail from Questacon. The advance notice provides information about the science circus, the areas that would be covered in the next year's science circus visit, the cost and an 'Expression of Interest' form for the school to return to Questacon if they are interested in the science circus program. This is not a booking form. Once the school returns the expression of interest form, Questacon then sends a booking information package to the schools by post early in term 4 of the year preceding the planned tour. Examples of the advance notice and the expression of interest form are available in Appendices A and B respectively.

In the booking information pack, Questacon sends a booking information sheet and a school booking application form. In the booking information sheet there is a brief explanation about the science circus program (science show, teacher workshop and public exhibition), tour details and more information about the nature of the science shows. On the booking information sheet, the school needs to fill in the school details and other required information related to the science circus event. On the reverse side of the sheet, a brief description of the topics of the different science shows is provided. However, it is explained that Questacon cannot guarantee which topics the schools would get. Examples of the booking information and school booking application are available in Appendices C and D.

The schools can send the booking application to Questacon through a free fax number, by post or online through the Questacon website. Usually Questacon starts to receive the completed booking forms in October. Questacon confirms their acceptance with a fax with information that Questacon will contact the school again after the booking schedule is finalised (about 2-3 months before the actual visit).

The booking officer's job becomes more demanding at this stage because they need to start arranging the route of the tour. This responsibility includes matching the demand of the schools with resources available (route and distance, maximum number of science shows and teacher workshops and time allocated). Arranging a single show for a cluster of very small schools is sometimes necessary. These arrangements are followed up by phone and by sending a reminder fax. The outcome of this tedious process is the establishment of a draft booking schedule. Sometimes the booking officer still has to rearrange and readjust the schedule as unexpected things happen at the last minute. After the booking schedule is ready, the booking officer sends each school a booking confirmation with details of the show time and school details including student numbers, grades, venue and school willingness to accept media and media photographer. The school is required to check whether the information is correct and send it back to Questacon.

Finally, prior to the tour, Questacon sends a final confirmation package to the school. The package consists of a covering letter, a parent information flyer, the Questacon learning experience information, information about the show topics, information about ticketing, a list of teacher workshop participants, a public advertisement for the school newsletter and for the staff notice board, some public exhibition posters, a volunteer explainer form and a Questacon brochure. Some of the information is colour coded to make differentiation easier.

2.9.3 Science circus in action

The Shell Questacon Science Circus has three components in the tour, they are: science shows, a public exhibition and a Professional Development teachers workshop. Each component will be explained in the following sections.

2.9.3.1 Science shows

From the beginning of the graduate diploma course, each member of the science circus is trained to master and develop two of thirteen shows available. From previous experience, Questacon recognises that some shows are more popular than others. The most popular shows are liquid nitrogen and collision shows. To cope with this, more science circus members master the popular shows compared to others. For example, in 2005 there are three science circus members working on the liquid nitrogen and collision shows while other shows only have two or even one member working on them. When performing in the schools, each member can choose which show he or she wants to perform although they do need to have the skill to readjust the content and language to match the audience's level of understanding.

The booking coordinator allocates the schedule but does not choose who goes where (for example, two members might have to go to one school for two sessions then go for another two sessions to a second school while another two members have to run four shows in a third school, and so on). During the first week of the trip the tour coordinator and a member of the science circus called 'big brother' (the person will change for each trip) would determine which pair of performers goes to which schools. For the following weeks, the coordinator holds discussions with all the science circus members to decide the allocation of schools. This is why it is not possible for the schools to guarantee certain shows. At the time the school booking is finalised, the decision about who goes where has not yet been made. Each performer has mastered only two shows and they can choose which show they prefer to perform in the schools they are assigned. Ideally 120 students is the maximum number for each session with 70-80 students as the average.

One session usually lasts for one hour and consists of two shows (each member performs one show for about 20 minutes). Between the shows there is a short science demonstration called a 'busk'. All shows use simple commonly found materials. The shows try to demonstrate science as part of everyday life in an entertaining way. There are 13 topics available: Balance, Balloons, Bubbles, Collisions, Flight, Friction, Liquid Nitrogen, Music, Pressure, Roundabout, Shark, Slime, and Structures.

1. Balancing the improbable

   This show explains an object's balance point and its importance. The science concepts covered include: balance points and balancing objects, hanging objects, stable objects and flying objects.

2. Balloon show

   This show uses balloons to demonstrate the concepts of elastic membranes, pressure and fluid motion. Scientific concepts involved in this show include: volume and air pressure, density, resistance, friction, static electricity, the Bernoulli principle, Newton's 1st Law of Motion, hot air balloons and properties of balloon rubber.

3. Bubble show

   This show uses bubbles to explain the properties of detergent films. Some of the scientific concepts explained include: stretchy films, surface tension and area, elasticity, bubble formation, shape and volume, light and colours.

4. Collision

   This show explains what happens in a collision. Scientific concepts covered include: energy transfer, conservation of energy, potential and kinetic energy, friction, impact forces, grip, and spin.

5. Flight

   This show investigates various concepts of flight. The main concepts covered include: lift and buoyancy, force for forward motion and thrust, speed, deflection manoeuvring techniques in aircraft and air resistance.

6. Friction

   This show explains what friction is, how it happens, how friction can be used to change other forms of energy into heat and how to reduce friction.

7. Liquid Nitrogen

   Scientific concepts covered in this show include: states of matter (solid, liquid and gas), changes in temperature caused by expansion and contraction of matter, and other changes in behaviour and properties of materials with changes in temperature.

8. Music show

   This is a show about the science behind sound and music. The science concepts covered in this show including: vibrations, sound waves, amplification, resonance, frequency, pitch and musical instruments.

9. Pressure

   This show explains the relationship between pressure, force and area, pressure in fluids, Pascal's principles, pressure and volume of a gas and Boyle's law.

10. Science Roundabout

    This show covers the science behind rotational and circular motion. It relates to everything that goes round. The science concepts covered include: linear inertia, moment of inertia and conservation of angular momentum, the stability of rotating objects, conservation of angular momentum in three dimensions, axis of rotation, centripetal and centrifugal forces.

11. Shark

    This show covers information about sharks.

12. Slime

    The major aim of this show is to demonstrate how fluids flow. The science concepts covered include: fluids and viscosity, Newtonian and non-Newtonian fluids, stir-thinning and stir-thickening fluids and cross-linked polymers.

13. Structure

    The structure show introduces a number of concepts that are related to the materials and shapes used in building. The science concepts covered include: pushing and pulling forces, strong shapes and how structures can be made stronger and lighter.

Science shows are a different way to experience science. Falk & Dierking (1992) stated that a science show is a kind of exhibit that allows people to experience real things from the real world as humans have many ways to experience through seeing, touching, tasting, feeling and hearing. Unfortunately, not much research has been carried out, especially on the impact of such shows on teaching practice. In this study, I analyse this effect from the teachers' perspective.

2.9.3.2 *Public exhibition*

As mentioned earlier, the science circus brings 50 interactive exhibits, loaded in a big truck. The big truck parks at the venue for the public exhibition, catching attention with interesting and colourful images of modern science and technology and astronomy that are painted on each side.

The science circus team meets the truck at the venue. The science circus coordinator briefs the team about the arrangement and venue's setting. The main task is to unload the 50 exhibits and set up the venue. The team works together and the job can be done in about an hour. Once it is finished, the science circus is ready to accept eager visitors from the town and nearby.

The science circus coordinator assigns each member different roles in the public exhibition. Some members are responsible for the entrance, selling or collecting tickets from visitors, some members act as explainers of the exhibits on the floor. Another member is responsible for performing the science shows that are scheduled while some other students are responsible for taking care of the shop that sells inexpensive interactive science toys and activities.

The public exhibition event is open to everybody, and is relatively inexpensive to access. The students and the teachers who were watching the science shows at schools receive a free entry ticket.

2.9.3.3 *Teacher workshop*

The science circus also conducts a Professional Development workshop for primary school teachers. This is a two-hour activity session where the teachers explore science concepts. It uses simple materials, which are available in everyday life. The workshop is designed as practical, hands-on experience for the teachers, providing the opportunity to pick up new ideas for teaching science and technology in a fun way. The activities have links to Australian curriculum profiles.

Usually the workshops are conducted by providing tables with equipment that the teachers can 'play with'. Some of the science circus members are available to assist the teachers in this workshop.

2.9.4 On the road in New South Wales tour, February – March 2005

All of the members of the science circus and the coordinator fly or drive to the starting location. For the trip analysed in this study they flew to Brisbane then rented cars to start the journey following the schedule. The regional towns covered were: Tenterfield, Casino, Glen Innes, Inverell, Armidale, Moree (Walgett), Narrabri, Gunnedah, Coonabarabran and Tamworth.

There were 15 science circus members for 2005. The members perform the school science shows in pairs, therefore there were 7 groups and one extra person available. All groups were capable of delivering the science shows and the teacher workshops. The tour coordinator would also support the teacher workshops. The extra person could perform on their own in small schools with low student numbers. In some areas, the teams would split up to reach more schools. On this trip, the teams were split up in Glen Innes, Inverell, Narrabri, Gunnedah and Coonabarabran.

They were 207 schools covered on this trip. A total of 18,348 students watched the science shows either in their school or in a nearby school (if the schools are very small they need to cluster with some other schools).

2.9.5 Past evaluation of science circus

Some evaluation and research has been done in the past regarding the Shell Questacon Science Circus.

Barbagallo (1997) investigated the effectiveness of the science circus in meeting its goals and objectives. This research was conducted as a component of a Masters degree in Scientific Communication at the Australian National University.

The goals of the science circus were stated to be: (1) to promote a positive and personally relevant image towards science and technology to the people of regional Australia, (2) to take a world class, touring, Science and Technology public program to the people of regional Australia, (3) to assist teachers in regional Australian schools to enhance the quality of science and technology education they deliver to their students, (4) to provide a diverse range of opportunities and audiences for the Graduate Diploma scholars to develop their skills in scientific communication, and (5) to be a well managed, cost recoverable program.

The objectives of the science circus were: (1) to generate awareness of the science circus as a major program of Questacon, (2) to optimise the number of people who will visit the science circus, both in schools and at venues, through generation of a broad interest base in the regions being visited, (3) to assist in promoting the national profile of Questacon, (4) to assist in promoting the national profile of the Shell Company of Australia, and (5) to provide opportunities for the Graduate Diploma scholars to work with media and the general public and develop their science communication skills.

Barbagallo used various tools such as: questionnaires for students and teachers, attitudinal instruments for students to test the stereotypes that they hold about science and scientist, interviews with teachers, polls from the science circus exit door, interviews with parents, participant observation and interviews with Graduate Diploma scholars.

It was clear from Barbagallo's results that both primary and high school students appreciate the role of science and scientists in society. However, primary school students have more positive images of science than high school students. Barbagallo also found little evidence that the hour long visit of the science circus to the schools could change the attitude of either primary or high school students. Barbagallo did suggest, however, that there was an opportunity to make more of an impact through collaboration between teachers, Questacon and other travelling programs.

All evidence suggested that the science circus was a world-class travelling program which is accepted widely by its audience within Australia. It is being imitated by other countries and subsequent employment opportunities, even overseas, for its graduate students are good.

Based on the responses of primary school teachers interviewed, in order to be able to assist them more the science circus needed to provide more resource materials that were related to the science shows and curriculum. High school teachers requested that the science circus provide more 'sophisticated' science shows that the teachers could not do themselves. They also requested more interactive resource materials and support.

From the interview with the Graduate Diploma scholars, it was concluded that the scholars were satisfied with the opportunities provided by the science circus. It was clear, therefore, that the science circus fulfilled the goals and objectives in relation to the scholars.

The science circus goal to be a well-managed, cost recoverable program was not analysed as it was considered to be an internal issue that Questacon management would be able to evaluate better.

The results for the science circus objectives were as follows: the science circus was achieving its targeted number for schools and public-venue visitors, however, improvement could be made to increase the number of visitors by an effective advertising strategy, making an effort to coordinate better with teachers and to promote the circus earlier before the actual visit.

The science circus was proven to be a good tool to promote the national profile of Questacon. Results from questionnaires showed that the majority of teachers and visitors to the public venues were also aware that Shell is the major sponsor of the science circus.

The most comprehensive research into the science circus was carried out by Rennie and Williams (2000). They conducted an evaluation of the educational effectiveness of the Shell Questacon Science Circus Program in fulfilling three of its objectives.

The first objective of the science circus was to promote science among people in regional Australia, particularly young people; in particular, to give positive and personally relevant images of science and technology, of scientists, and of careers in science and technology. The second was to provide access for people of regional Australia to a world class, touring, public science and technology program. The third objective was to assist teachers in regional

Australian schools to enhance the quality of the science and technology education, which they offer their students.

Rennie & Williams (2000) collected data from three sources. Firstly, a comparative review was conducted on two similar travelling science programs: National Science-Technology of New Zealand and Queensland Science centre. Secondly, a review was conducted of previous research and evaluations on the science circus. Thirdly, the researchers conducted interview sessions by phone to school teachers whose schools had been visited on certain tours.

Overall, very positive results were gained from this evaluation. Teachers and visitors acknowledged the scholars' professionalism and enthusiasm. Visitors (public and students) enjoyed the science circus especially the hands-on aspect. They reported that science was portrayed as fun, interesting and relevant to everyday life for normal people, and that the science circus provided an accessible opportunity for students and public in rural regions.

Rennie & Williams (2000) made some recommendations to improve science circus practice. With regard to the content and structure of the science shows they suggested an increase in the use of words like 'science' and 'scientist' to familiarise the audience. They encouraged more discussion on science as a career in order to portray science as a good career and to promote science, and they encouraged using student volunteers as much as possible. With regard to the science circus in general, they advised that the circus continued to carry out promotion through schools and local media, and continued to update information on the Questacon website and provide useful links for students, teachers and parents on science related information. Suggestions to improve the value of the science shows for the audience were: to provide a broad range of science shows suitable for its audience age groups, to find more ways to provide teachers with information about the science show before and after the circus visit, and finally, to improve options for professional development.

Burns (2003) provided the latest evaluation of the effectiveness of the science circus shows. In this study Burns used case studies to analyse the effectiveness of science shows for science communication. The Shell Questacon science circus was one of his major case studies and focused mainly on the scholars and the major sponsor. The results of this study showed that the scholars and Shell Australia were both satisfied with the course. The science circus was mentioned as one of Burns' major case studies, however very little information was provided. There was only a brief three page explanation on what the science circus is, a brief history of the science circus and a description of the operation of the science circus and the science shows. There was a very brief explanation, less than one page, on how the scholars and sponsor were satisfied with the science circus.

Burns (2003) used a vowel analogy, AEIOU, to evaluate science shows, which represents **A**wareness, **E**njoyment, **I**nterest, **O**pinion forming/reforming/confirming, and **U**nderstanding. Fulfilment of the AEIOU factor was used as one tool to measure the effectiveness of science shows. By using this, Burns (2003 p. 211) expected that:

> "Within the constructivist view of the world, science shows will make a contribution – positive or negative – to a person's science AEIOU."

I will look at Burns' vowel analogy briefly when I discuss the results of my study in Chapter 5.

2.10 Conclusion

This chapter has discussed the importance of science and noted the declining interest of students in studying science. It reviewed some problems of science education, especially in Australia and in Indonesia, and identified the role that science centres play in informal learning. Finally it discussed travelling science centres, and the Shell Questacon Science Circus in particular, which was the subject of the present research.

Chapter 3 Methodology

3.1 INTRODUCTION

This chapter describes the method used in the research. The study aims to analyse the effect of the science circus science shows on the teaching practice of teachers, based on their own views of its impact. This research uses a qualitative method including preliminary observations, data collection, and evaluation.

The research questions for this study are:

- Does the science show performed by the science circus in schools affect teachers' classroom practice in any aspect?
- Is the science circus a feasible model for Indonesia?

A questionnaire was chosen as the most appropriate tool for data collection. The questionnaire was addressed to the teachers who accompanied students and watched the science shows. Invitation to participate in this study was sent to all schools that booked the science circus during one particular trip to northern New South Wales from 26 February – 24 March 2005. Participation was completely voluntary.

3.2 THE RESEARCH METHODOLOGY

Fink (1995) defined surveys as information collecting systems to illustrate, compare, or explain knowledge, attitudes, and behaviours. They involve many things including: setting objectives, designing research, preparing an appropriate data collection instrument, administering and scoring the instrument, analysing data and reporting the results.

Questionnaires have been widely used as data collection instruments for survey data (De Vaus, 1995; Wadsworth, 1997). Questionnaires are often designed to obtain qualitative information in a method that may be measured quantitatively when analysed (Wadsworth, 1997). However, questionnaires also have the disadvantage of leaving the researcher unable to clarify the answers or get supplementary explanations.

There are many reasons why questionnaires need a high level of skill to manage. Wadsworth (1997) mentioned some of the reasons. Firstly, the usefulness of the questions included needs to be carefully considered. The respondents may answer yes for a certain question but they might only mean yes under certain circumstances. Secondly, inappropriate sample selection can cause irrelevance. For example, a questionnaire about job satisfaction is irrelevant to a person who is not employed. Thirdly, questionnaires sometimes simplify the situation and therefore distort the real problem. A final issue is consistency. Often there is a great difference between what people say and what they actually do.

Oppenheim (1992), De Vaus (1995), and Foddy (1996) emphasised the importance of questionnaire design. This is an important step in order to ensure that information gathered from the questionnaires can be used for further analysis. Utwin (1995) claims that good surveys provide critical information and act as a key into the core of the subject of interest.

Questionnaire surveys can be done in several ways. Generally, the questionnaires are sent, posted or handed to participants for them to fill in (Wadsword, 1997). This first method is often called the self-administered questionnaire and can be done electronically by e-mail, by using the regular postal service or physically, by handing the questionnaire to the participant. The second method of gathering data is by interview. The researcher or a professional interviewer can hold the interview either by meeting the interviewee in person or by phone. The same set of questions must be used every time to ensure consistency. The interview method allows the interviewer to clarify interviewee's answers.

De Vaus (1995) stated that the method of managing the questionnaire would also affect what type of questions can be asked. The design of a self-administered questionnaire should focus on simplicity and clarity. Questionnaires that are managed by a professional interviewer, however, can be designed with more complex questions to obtain more comprehensive answers as the interviewer may ask for clarification from the respondents.

The most common data collection method used is the self-administered questionnaire. Usually the questionnaire is sent together with a covering letter (Punch, 2003). Oppenheim (1992) stated the advantages of mail questionnaires as being a low cost method of data collection and processing, ability to prevent interviewer bias and ability to reach respondents who live in dispersed areas. However, mail questionnaires also have some disadvantages: low response rates that can result in biases, no opportunity to correct misunderstanding, no control and check on incomplete responses, no opportunity to collect assessment based on observation and unsuitability for respondents with low literacy. Punch (2003) and Wadsworth (1997) claim that the length of the questionnaire is an important issue that influences the response rates. Shorter questionnaires can increase the respondent's willingness to participate in the study.

Oppenheim (1992) and De Vaus (1995) suggested the use of an incentive to increase the return-rate. Burns (2003) supported this theory in his research. Burns reported an increase in response rate to an average of 25% by offering some prizes to one or two randomly selected respondents who were willing to complete his evaluation survey.

There are two types of questions that can be used in a questionnaire: closed and open questions. Closed questions provide some pre-set answers from which the respondent can choose while open questions simply ask the respondents' opinion and allow the respondents to formulate their answers and express their opinions more freely.

Foddy (1996) summarises some issues regarding open and closed questions. Open questions enable respondents to express themselves in their own words, do not suggest answers, avoid format effects (sometimes the format of provided answers may affect the answer choice), facilitate comprehensive answers; and can function to help the interpreting of unusual answers in closed questions. Closed questions have their own advantages, such as providing comparable answers as all respondents answer in a standard response format and so generate less variable answers. It is easier to answer closed questions compared to open questions. The results are much easier to process and analyse.

Oppenheim (1992) has a similar opinion to Foddy. In addition, Oppenheim sums up the disadvantages for both methods. The open questions are generally time-consuming, more difficult to process with the possibility of being unreliable and they demand more effort from respondents. Closed questions, however, also have their own disadvantages such as being biased in answer categories. They may irritate respondents and will obtain less spontaneous responses.

The questionnaire has to be designed to maximise clarity and simplicity (De Vaus, 1995). Questionnaires that consist of both closed and open questions can maximise the advantages of both methods (Foddy, 1996). Closed questions encourage more participation because they are naturally easy to answer. However, open questions are also needed to explore the more comprehensive input that is invaluable to a study. Semi-open questions can also be used. For this kind of question, participants are asked to choose from available options (closed question) and are also asked to explain it further in the space provided (open question). Wadsworth (1997) comments on the danger that respondents who may choose one answer for a certain question may only mean it under certain circumstances. Providing semi-open questions that allow the participant to explain their answer can reduce this risk.

3.3 THE RESEARCH DESIGN

This study, which aims to analyse the affect of the science circus science shows on the teaching practice of teachers used a mixture of open, closed and semi-open questions. The research design had a series of preliminary steps before the questionnaire was posted to schools.

3.3.1 Preliminary observation

I conducted a preliminary informal observation to look at the real operation of the science circus more closely. The observation took place on the science circus last trip to Victoria in 2004. I joined the science circus in a region called Echuka and attended shows in several schools. Based on these observations, research questions were designed for the questionnaire used for the study.

A self-administered questionnaire was considered to be the most suitable tool to gather data from teacher respondents. After I designed the questionnaire, it was reviewed by two visiting fellows at the Centre for Public Awareness of Science, ANU. Both fellows were experts in the field of science teaching and informal science learning. Approval from the Human Research Ethics Committee at the Australian National University was obtained on 3rd March 2005 under protocol number 2005/8. A copy of the approval is available in Appendix E.

The research questionnaire was designed to be one page long with the aim of maximising the return rate (Punch, 2003; Wadsworth, 1997). The questionnaire consisted of open, closed and semi-open questions to maximise the advantages of each type.

3.3.2 Selection of subjects

The information was gathered from one particular science circus trip from 26 February – 24 March 2005 to northern New South Wales. There were 207 schools visited, with students' age ranges from kindergarten to high school level. The questionnaire was sent to all schools visited on this trip. The questionnaire was addressed to teachers who accompanied the students and watched the science shows at the schools.

3.3.3 Data collection

All the information packs were sent to the schools in early May 2005. Every school received the same information pack consisting of an invitation letter, an information sheet and questionnaires, following the recommendations of Punch (2003). The invitation letter encouraged teachers to participate in the study. The information sheet explained the nature of the study, the aims, confidentiality information, and information required to fill in and return the questionnaire. The questionnaire could be reproduced for all teachers who watched the science shows and were interested in joining the study. A copy of the invitation letter, information sheet and questionnaire can be found in Appendices F, G, and H respectively.

After sending the information pack, all schools were alerted by a fax explaining the project. Two weeks' time span was given to participants in which to respond. The first due date was on 13 May 2005. After the closing date, a reminder and thank you fax was sent to all schools on 23 May 2005 (Appendix I). The fax thanked the teachers who already participated and also encouraged participation by teachers who had yet to respond. Another week was given to allow more participation and increase the return rate. The final deadline was 1 June 2005.

3.3.4 Questionnaire

The questionnaire was posted in early May, about two months after the science circus performed the science shows in the schools. The reason for this was to allow enough time for teachers to do follow up activities and reflect on their own teaching practice after the science circus visit.

Questacon itself was responsible for posting the questionnaires to all schools visited during the February – March 2005 trip. This was done to satisfy several ethical considerations. The schools contact details are confidential and must not be shared with a third party, including the researcher. Questacon acted as the intermediary between the schools and the researcher, faxing the questionnaires and information required for this study and receiving the questionnaires returned by the participants.

I also provided an incentive in order to increase the return rate (as recommended by De Vaus, 1995 and Oppenheim, 1992). All teachers who participated in this study would be included in a lucky draw to win a prize. The prize was four books called '101 cool science experiments' (Singleton, 2004). A free fax number was provided to make it convenient for the respondents to return the questionnaire and to avoid participants' concern about the cost.

3.3.5 Research questions

The questions in the questionnaire were carefully designed to inform the main research question: "Does the science show performed by the science circus in schools affect teachers' classroom practice in any aspect?"

My second question is a sub-question related to Indonesia: "Is the science circus a feasible model for Indonesia?" A literature study on the Indonesian and Australian education systems and science teaching practices in Chapter 2 addressed the background information needed. The discussion in Chapter 5 will answer this question.

3.3.6 Overview of method

I summarise the steps I used for this study in Table 4.

Table 4: Overview of method

Activity	Timeline
An informal science circus observation	Nov 2004
A questionnaire draft was designed	Dec 2004
The questionnaire was submitted to the ethics committee in ANU	20 Dec 2004
Ethics committee approval was received	3 March 2005
The questionnaire was reviewed by two CPAS visiting fellows	March 2005
Observation for the trip evaluated in New South Wales area	March 2005
The questionnaire was revised	March 2005
The questionnaire was handed to Questacon to be posted	early May 2005
The questionnaire was sent to 207 schools by Questacon on my behalf	early May 2005
An alert fax was sent immediately by Questacon after posting the questionnaire	early May 2005
Questacon received the questionnaires back from the participants through fax	until 13 May 2005
Questacon faxed another encouragement reminder and thank you note on my behalf. The closing date was extended to 1June 2005.	mid May 2005
Questacon received more questionnaires	until 1 June 2005
Questacon sent the incentive to the winner on my behalf	June 2005
Questacon handed all questionnaires received to me	June 2005

3.3.7 Rationale for questions

Question 1: Which class level do you teach?

Question 2: Which class level did you accompany in the Science Circus show?

Questions 1 and 2 were designed to answer basic demographic questions. The answers to these questions provide a picture of the people who were interested in participating in this study without having to ask personal questions.

Question 3: Which show did you see?

Question 3 was needed to identify and evaluate the show. This question was included to test the impact of the science show. This is based on the assumption that good shows would remain longer in the memories of the participants.

Question 4: Has your school booked the Shell Questacon Science Circus before?
yes
no
I don't know

Question 5: How did your school learn about the Shell Questacon Science Circus (you may answer more than one)?
from the offering letter sent by Questacon
word of mouth, e.g. from other teachers
publications in media: newspaper or radio
other, please mention: ______________________

Questions 4 and 5 were included to gather data on the participant's familiarity with the science circus and to determine how they learnt about the program.

Question 6: Do you think that your students enjoyed the show?
very enjoyable
generally enjoyable
some enjoyed it, others not
generally did not enjoy it

Question 6 was included to determine the students' enjoyment based on the participants' observation. Teachers are in a better position than the science circus members to assess the students' enjoyment of the shows. The aim of the science circus is to entertain and provide enjoyment for the audience. Therefore student enjoyment is a valuable indicator of the success of the show.

Question 7: Please make a comment about the show that you saw in your school: __________
____
____

Question 7 was looking for the participant's comments on any aspect of the show that they considered important. This question was left open so as to capture as broad a range of reactions to the science shows as possible.

Question 8: Would you book the Shell Questacon Science if it were available in the future? yes no

Question 8 was included based on assumption that willingness to book in the future can be used as one indicator of satisfaction.

Question 9: Do you think the visit had longer-term outcomes for students? yes no Please explain: ______________________________ ______________________________

In Question 9, no suggested answers were given, as I wanted the participants to respond with any possible opinion about science circus outcomes (whether educational or not) and to minimise bias.

Question 10: Did you / will you do any follow up activities for students in class? (e.g. discussion, repeating the science show, explaining the science behind the show, asking students to write a report, using the post visit materials given by the Shell Questacon Science Circus team, etc). yes no Please explain: ______________________________ ______________________________

Question 10 was included to provide the necessary backgrounds to answer my research question. Given that this was about two months after the visit, I wanted to know whether teachers had already carried out any follow up activities or planned to do any. Some space was available for the participants to explain their answers. I provided several follow-up activity examples, not to influence the participant but to provide some hints and explain what I meant because further clarification was impossible. De Vaus (1995) emphasised that questions in a self-administered questionnaire should be designed carefully, as further clarification is not possible.

Question 11: Has your own teaching been influenced in any way after the Shell Questacon Science Circus visit?

yes

no

Please explain: ____

____

Question 11 was included to provide a direct answer to the research question. The question clearly asks whether the participant's teaching practice has been influence in 'any way' to allow for positive, negative or unexpected answers.

Question 12: Do you have any general comment / suggestion to improve the show that you saw in school? ____

____

Question 12 was included to give opportunity for the participants to provide any suggestions to improve the shows. It also provides further opportunity for the participants to clarify their satisfaction or dissatisfaction with the show.

Question 13: Any other comment? ____

____

____

This last question was included as an opportunity for the participants to express whatever they considered important regarding the science circus, which had not already been covered in the questionnaire.

The list of questions as mentioned above can be classified into groups. Some questions can be classified into more than one group as they can serve different purposes.

Group 1: demographic information

Questions 1 and 2 provided demographic information.

Group 2: familiarity with the science circus

Questions 4 and 5 helped to check this issue.

Group 3: evaluation of the science shows

Questions 3,6,7 and 12 were classified in one group, to evaluate the science shows.

Group 4: the impact of the science shows

Questions 6,7,8,9,10, and 11 were grouped together provide information regarding the science show's impact.

3.3.8 Data processing and analyses

I received the completed questionnaires from Questacon for further analysis. The results of some of the questions can be summarised numerically. Questionnaires are designed to obtain qualitative information in a method that may be measured quantitatively when analysed (Wadsworth, 1997). Descriptive statistics are presented as a summary in tables accompanied with bar charts whenever appropriate. For open answers, I categorised similar answers, therefore allowing a numerical summary to be obtained. Some questions contain answers that can be put in multiple categories, therefore the numbers in the summary do not represent the number of people responding but the number of different answers. The results for each question are presented in Table 5.

Table 5: Data processing and analysis

Question	Type	Information	Result presented in
Q1	Open	Class level taught by participant	Bar chart
Q2	Open	Class level accompanied to the shows	Bar chart
Q3	Open	Which show the participant saw	Table and bar chart
Q4	Closed	Previous booking information	Table
Q5	Closed	Source of information about science circus	Bar chart
Q6	Closed	Students' enjoyment of show	Table
Q7	Open	Comment about the show	Table and classification
Q8	Closed	Future booking possibility	Table
Q9	Semi-open	Longer-term outcomes	Table and classification
Q10	Semi-open	Follow up activity	Table and classification
Q11	Semi-open	Teaching influence	Table, classification, and bar chart
Q12	Open	Suggestion to improve the show	Table, classification, and bar chart
Q13	Open	Any other comments	Table and classification

3.3.9 Limitations of the research method

Ethical guidelines prevented Questacon from sharing the contact details of the schools with the researcher, therefore direct contact between researcher and the schools was impossible. Questacon is not permitted to provide the address and phone number of schools, which prevented me from conducting the survey by phone interview. The only way to solve the problem was by using Questacon as the intermediary. Questacon handled all correspondence including sending and receiving the questionnaires on my behalf. Being unable to contact the teachers in person, I was also prevented from prototyping the questionnaire. To overcome this, the questionnaire was reviewed by two visiting fellows at the Centre for Public Awareness of Science, ANU.

Time and location constraints were also major limitations for this study. It was impossible to do the research by any other method – for example by face-to-face interview – because of time and location constraints as well as ethical considerations.

Self-administered questionnaires also have limitations as the respondents' answers can not be clarified. Therefore interpretation bias might occur. Moreover, I had no access to the schools' contact information, making it impossible to contact them for further explanation or clarification.

Further limitation: somewhat limited opportunity for follow up, dependent in Questacon's good will and inability to contact teachers directly.

3.4 Conclusion

This chapter has explained the theory behind the method used in this research and has described the design of the questionnaire used. The data gathered from the questionnaire will be presented as results in Chapter 4. Discussion in Chapter 5 will analyse the results and answer the research questions.

Chapter 4 Results

This chapter presents the results obtained from the questionnaires. The results help to answer my research question: "Does the science show performed by the science circus in schools affect teachers' classroom practice in any aspect?"

4.1 Sample

A self-administered questionnaire was sent to 207 schools and the total response received was 71 questionnaires. Two were invalid as they were blank and one expressed regret for not being able to participate in the study. The responses came from 41 different schools, with some schools sending more than one questionnaire. A total number of 68 valid questionnaires were processed for further analysis in this chapter.

4.2 Return rate

I made every attempt to maximise the return rate. The questionnaire was designed to be one page long to encourage participation (Punch, 2003; Wadsworth, 1997). A free fax number was provided for questionnaire return to avoid concern about cost on the part of the school. A fax alert was sent immediately after the questionnaires being posted to the schools. A reminder and a letter encouraging participation was faxed to all schools, and the closing date was extended to provide more time for participation. An incentive was offered for teachers who participated in this study in an attempt to increase the return rate (Oppenheim, 1992; De Vaus, 1995). All teachers who returned the questionnaire were included in a lucky draw. The winner was randomly chosen and four science books were sent to the chosen teacher.

Out of the 207 schools involved in the survey 41 responded, giving a return rate of 19.81%. Oppenheim (1992) lists a low response rate as one of the disadvantages of a mail questionnaire. There are many possible reasons why the teachers decided not to participate in this study. I made every attempt to increase the return rate by sending an encouragement letter after the closing date on 13 May 2005 and extending the closing date to 1 June 2005. Ultimately I had to proceed with the data received by the extended closing date. Although the return rate was not very high, the input received is an invaluable contribution with which to answer the research questions.

The average response was 98% for closed questions, 84% for open questions. Some questions combined open and closed questions together (semi-open questions). In this type of question, usually the participant was asked to choose from answers available (closed question) and then the participant was also asked to explain their answer (open question). For semi-open questions the average responses for the closed part and open part were 98% and 84% respectively. It is not surprising to note that closed questions had a higher response rate compared to open questions because they are easier to answer (Foddy, 1996). Individual responses and percentage for each open, closed, and semi-open question are shown in Table 6, Table 7, and Table 8 respectively.

Table 6: Response to open questions

No.	Question	Valid n	Percentage
Q1	Class level taught by participant	65	96%
Q2	Class level accompanied to the show by participant	67	99%
Q3	Which shows were seen by the participant	59	87%
Q7	Comment about the show	65	96%
Q12	Suggestion to improve the show	44	65%
Q13	Any other comments	41	60%
	Average =	56.8 = 57	83.8%

Table 7: Response to closed questions

No.	Question	Valid n	Percentage
Q4	Booked the science circus before	65	96%
Q5	Source of information of the science circus	67	99%
Q6	Student's enjoyment of the show	68	100%
Q8	Future booking prospect	65	96%
	Average =	66.3 = 67	98%

Table 8: Response to semi-open questions

No.	Question	Valid n (closed question)	%	Valid n (open question)	%
Q9	Longer-term impact of the show	65	96%	62	91%
Q10	Follow up activity	68	100%	64	94%
Q11	Teaching influence	67	99%	46	68%
	Average	66.7 = 67	98%	57.3 = 58	84%

4.3 Results

4.3.1 Demographic information (Questions 1 and 2)

Which class level do you teach? (Question 1)

Sixty-five (65) participants responded to this question. Of those who responded, 62 were teachers and three were school principals. It is possible that some teachers taught a number of different class levels. The class levels that the participants taught are presented in the following bar chart below.

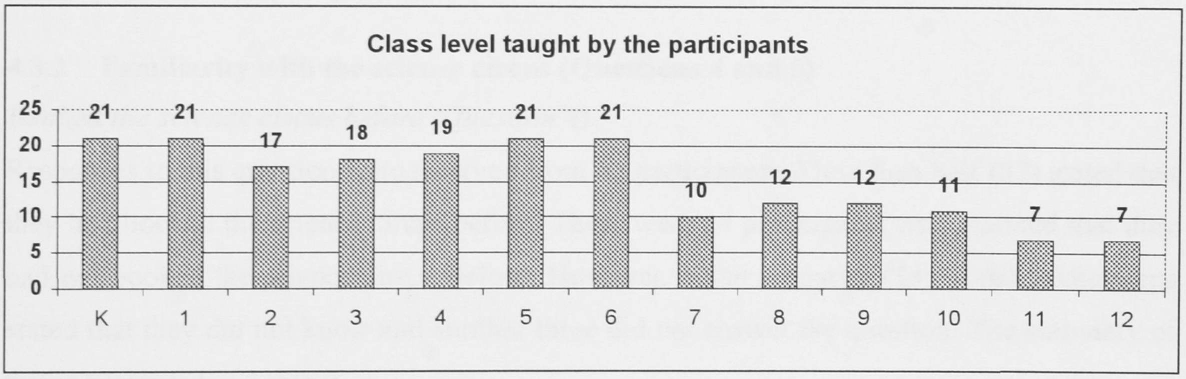

Figure 1: Class level taught by the participants

Which class level did you accompany in the show? (Question 2)

All participants but one answered this question. Figure 2 shows class levels accompanied by the participants presented in a bar chart. It is possible for some teachers to accompany more than one class level to the show. It shows that more primary students (kindergarten to year 6) were accompanied by the participants than secondary students (years 7 to12).

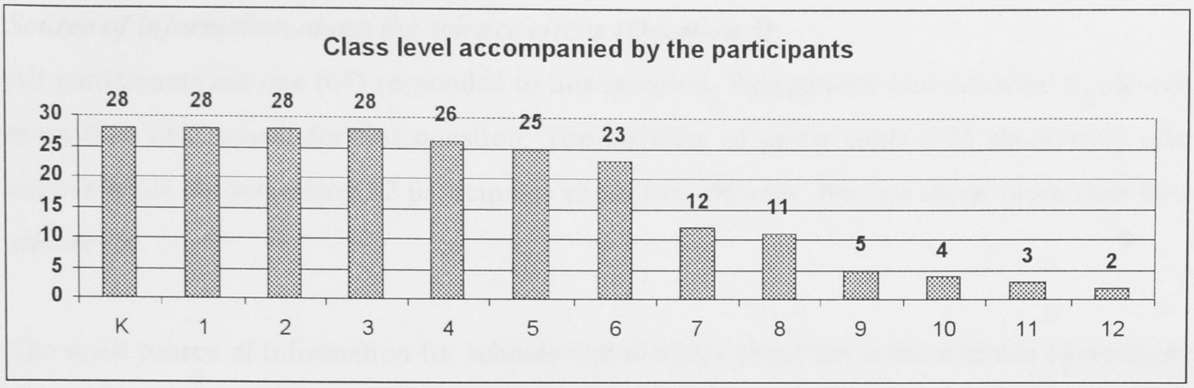

Figure 2: Class level accompanied by the participants

The results from questions 1 and 2 show that more participants taught at primary level and more primary level students were accompanied to the show. This result is not surprising as for the particular trip observed, the science circus was booked to visit more primary than secondary level schools. Data from Questacon for this trip, confirm that the science shows were attended by more than 11,000 students from schools teaching kindergarten to year 6, about 4,300 students from schools teaching kindergarten to year 12 and about 2,400 students from schools that only taught years 7-12.

4.3.2 Familiarity with the science circus (Questions 4 and 5)

Booked the science circus before (Question 4)

Responses to this question were received from 65 participants. More than half (37) stated that they had booked the science circus before. There were 14 participants who claimed that they had not booked the science circus before. However, about a quarter (14) of the participants stated that they did not know and another three did not answer the question. The summary of this is presented in Table 9.

Table 9: Previous booking information

Has your school booked the science circus before?	
Yes	37
No	14
Do not know	14
Did not answer	3

Source of information about the science circus (Question 5)

All participants but one (67) responded to this question. Participants were allowed to choose more than one answer for this question. The majority of participants (55) chose only one answer while the remaining 12 participants chose two answers. No one chose more than two answers.

The main source of information for schools and teachers about the science circus came from the introductory letter sent by Questacon. Other sources of information included word of mouth and publications in the media, but these were mentioned less often. Only a few participants mentioned other sources, such as a previous visit from the science circus, their own visit to Questacon in Canberra, phone contact from Questacon staff or a school newsletter. There was only one response where the participant stated they were unsure as to the source of information about the science circus. The bar chart in Figure 3 provides a summary.

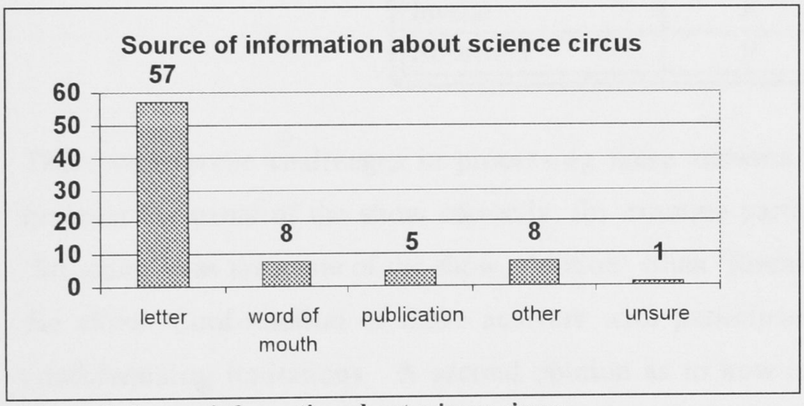

Figure 3: Source information about science circus

4.3.3 Evaluation of the science shows (Questions 3, 6, 7, 12)

A typical one-hour science show in a school consists of two shows with a short science show, called a 'busk', in between. A different presenter presented each show. Once the first presenter finished with the first show they continued with the busk. The busk was used to distract the audience whilst the second presenter prepared the next science show.

There are 13 standard science shows available and the presenters adjust the content of the science shows to correspond with the level of understanding of the audience.

Which show did you see? (Question 3)

This question aimed to challenge the participant's memory to test how well they could remember the shows two months after the visit. Answers were received from 59 respondents although 6 of them provided invalid answers. Examples of invalid answers include: 'science circus', 'Questacon' and 'Y3'.

About half of the participants (35) could mention the names of the two shows. Only a few (3) stated that they could not remember. Fifteen participants did not answer or provided invalid answers. These results are presented in Table 10.

Table 10: Category of participants answers for the shows they saw

Answered	Frequency
Mention 2 shows	35
Mention 1 show	15
Cannot remember	3
Invalid	6
No answer	9

There were some challenges in processing these answers. Some of the answers did not mention the name of the show correctly, for example participants mention 'Forces' when 'Structure' was the name of the show, 'Motion' when 'Roundabout' was the correct name of the show. Confirmation of these answers with participants was impossible because of confidentiality limitations. A second opinion as to how to deal with these answers was obtained through consultation with Professor John Rayner. Professor Rayner is a visiting fellow in the Centre for Public Awareness of Science (CPAS), ANU, who had observed part of the trip to the NSW area and evaluated the show's content. I discussed these vague answers with Professor Rayner and we categorised them into the appropriate show names.

The following Figure 4 presents the frequency with which each show is mentioned by the participants.

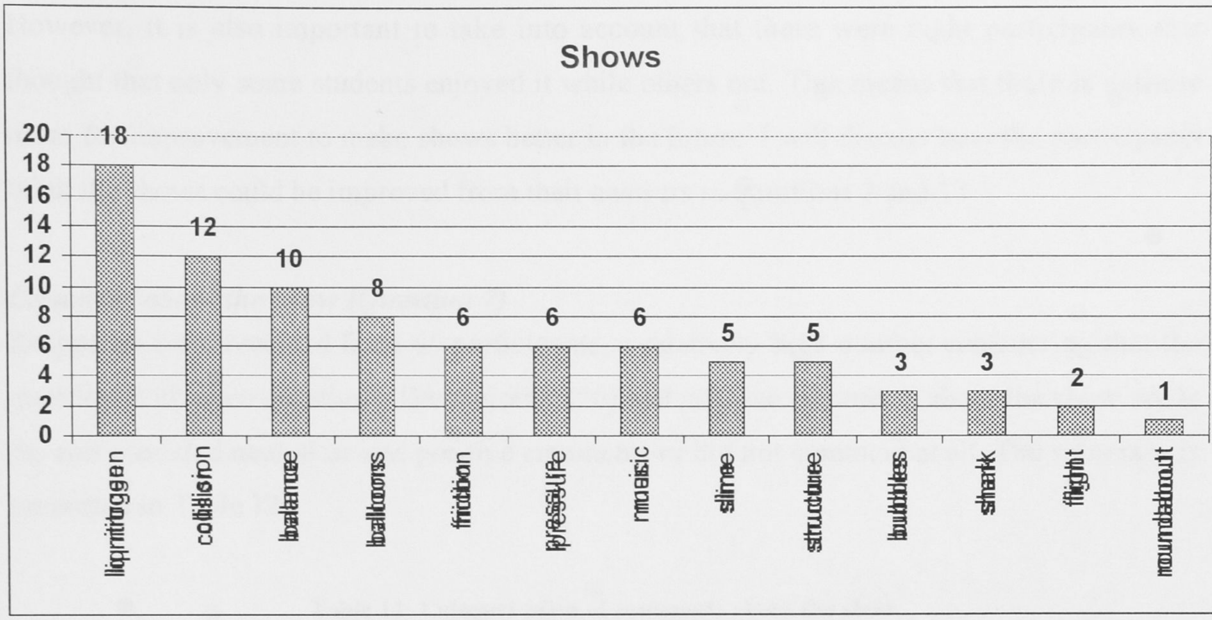

Figure 4: The shows that the participants saw

The 'Liquid Nitrogen' show was mentioned the most by the participants while the 'Flight' show was only mentioned twice. As mentioned in Chapter 2, the 'Liquid Nitrogen and 'Collision' shows were the most popular. Therefore there were three science circus members that had mastered each of these two shows. In general, one show is usually mastered by two science circus members or sometimes only by one person. The 'Shark' show for example was only mastered by one person. Unfortunately, there was no record of which shows were performed on the particular trip observed, therefore a comparison between the data gathered and the actual frequency of the shows cannot be made.

Show enjoyment (Question 6)

All participants answered this question. The results were very positive; almost two-thirds of the participants (44) claimed that the shows were very enjoyable. No one claimed that generally students did not enjoy the shows. The summary can be found in Table 11 below.

Table 11: Level of enjoyment of the shows

Do you think that your students enjoyed the show?	
Very enjoyable	44
Generally enjoyable	16
Some enjoyed it, others not	8

However, it is also important to take into account that there were eight participants that thought that only some students enjoyed it while others not. This means that there is definite room for improvement to make shows better in the future. I will discuss how the participants think the shows could be improved from their answers to questions 7 and 12.

Comment about the show (Question 7)

Responses were received from 65 participants, a relatively high number considering that the question is an open question. The majority (56) had positive comments about the show while the rest provided neutral or less positive comments or did not comment at all. The summary is presented in Table 12.

Table 12: Categorisation of comments about the show

Comment about the shows	
Positive comments	56
Less positive comments	6
Neutral (positive and negative)	2
No comment	4

<u>Positive comments</u>

General positive comments mentioned: the good performance, the presenters, the suitability for audience, audience participation, the hands-on nature, the capability to hold students' attention, being informative, being practical and the variety of the performances. Some participants had more than one positive comment as presented in Figure 5.

"Excellent, well suited to students ability and age."

Participant #2

"...Plenty of audience participation"

Participant #8

"The show was very well presented in an entertaining & informative way."

Participant #18

"It was a very interesting show which held the students attention."

Participant #21

"...Great practical..."

Participant #33

"Students enjoyed the 'hands on' side of the show."

Participant #50

"It was good to see a variety of experiments rather than focus on one specific area."

Participant #59

"Excellent show - the staff from Questacon really know their stuff and could entertain very well."

Participant #61

"We always love having Questacon visit - as one child said 'science is WOW' "

Participant #66

"The presenters were vivacious..."

Participant #67

Figure 5: Positive comments about the show

Less positive comments

Some participants commented less positively on various aspects of the show although in relatively small numbers (6). The issues raised were: the hands-on nature of the show, language problems, audience suitability, students' interest and presenter's ability to handle a large audience. I quote participants' less positive comments in Figure 6.

"Not enough hands-on for children. Perhaps better to have some hands-on activities after the session we had..."

Participant #29

"Too crowded some presenters had difficulty dealing with large number of children."

Participant #41

"A little too much talk - high level language was a bit much for younger children."

Participant #43

"The presenters couldn't speak English clearly enough for the children to understand."

Participant #51

"[The show] was not captivating enough to hold the interest of all students."

Participant #62

Figure 6: Less positive comments about the show

Regarding the language problem mentioned in the fourth comment in Figure 6, there was only one presenter with a non-english-language background. There were two participants (participant #51 and participant #52) who mentioned this language problem and both participants came from the same school. In addition, the trip being evaluated in this study was the first trip for all the science circus members so it was not necessarily their best performance.

Neutral comments

Three of the participants provided neutral comments mentioning both positive and negative aspects of the show.

"The show was exciting to begin with but students quickly lost interest."

Participant #25

"Not enough hands on activities for all students - great demonstration though."

Participant #42

"Forces was quite good with good student participation. The inability of the 2nd presenter to communicate and lack of hands on opportunities made the show very poor (shark)."

Participant #52

Figure 7: Neutral comments about the show

Regarding the comment from participant #52 in Figure 7, I need to clarify that the second presenter was the one who presented the shark show. I also need to clarify that the participant #52 was the same participant who made less positive comments about language skills of the presenter with a non-english-language background.

Comments related to specific shows

From all the comments received about the shows, only a few participants (6) refer back to a specific show. Some of these comments are presented in Figure 8.

"...*Enjoyed the egg dropping the most.*"

Participant #3

"...*Balancing clowns could be much larger.*"

Participant #4

"...*The music/sound show was presented brilliantly...*"

Participant #56

Figure 8: Comments about specific shows

General comments or suggestions to improve the show (Question 12)

This open question asked participants to comment and provide suggestions to improve the show. Forty-four participants responded to this question and the majority of participants (30) provided at least one suggestion to improve the show. The summary can be found in Table 13.

Table 13: General categorisation of comments to improve the show

Comments or suggestions to improve the show	
Satisfied	14
Improvement suggestions	30
No comment	24

Satisfaction of the show was expressed by 14 participants therefore these participants did not provide any suggestions to improve the show. Samples of their comments are presented in Figure 9.

"The show was great as it was..."

Participant #1

"It was a great, very informative show."

Participant #21

"Good interesting show."

Participant #57

"The show was fantastic and enjoyable."

Participant #60

Figure 9: Satisfaction expressed – no improvements suggested

There were 30 participants who suggested improvements for the shows. I categorised their comments as: (1) delivery (including language, communication techniques, and speed of delivery), (2) nature of the show (sophistication, length of show, and number of audience), (3) hands-on, (4) science concepts delivery, (5) pre/post visit materials, (6) equipment support, and (7) circus events for the public.

There were four participants who provided comments that could be placed into more than one category, therefore a total 34 comments were received from 30 participants. Samples of their comments are presented in Figure 10. The bar chart in Figure 11 presents the frequency for each category.

"Children found it difficult to understand the presenter with a very strong accent (delivery). *The children enjoyed the show - not sure if they followed the scientific concept."* (Science concept)

Participant #10

"Presenters need to be able to address children appropriately (at their level) (delivery - language). *Students become a little lost with some of the explanations. More hands on (stations)."* (Hands-on)

Participant #25

"Children need to be made more aware of what each experiment is teaching them (science concept). *Perhaps simpler explanations at the end or a post session w/s for class teacher to reuse content."* (Pre/post visit materials or follow-on)

Participant #29

"Use of more spectacular or thought provoking experiments (nature of the show - sophistication), *use of audio visual* (equipment), *to make it more captivating."*

Participant #62

Figure 10: Improvement comments that can be categorised in more than one category

Regarding the comment provided by participant #25 (Figure 10) about the hands-on suggestion, I would like to clarify that the shows were never advertised as hands-on. Detailed discussion about this is given in Chapter 5.

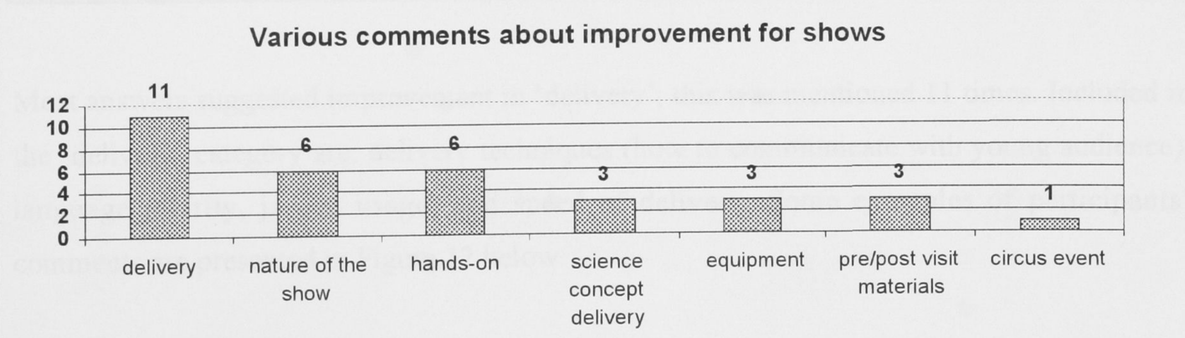

Figure 11: Categorisation of comments to improve the show

All the areas that were included in the improvement suggestions and their explanations are listed in Table 14.

Table 14: Factors needing to be improved

Suggestions for improvement	Explanation
1. Delivery	
- technique	- deliver the shows to the audience's level of understanding
- speed of delivery	- do not talk too fast
- language	- clarity when speaking, accented English, minimise the use of jargon
2. The nature of the shows	
- spectacularity	- use more spectacular experiments
- audience size	- too large
- length of the show	- make it longer (1.5 hours)
- music	- add circus music in the opening of the shows
3. Hands on	- not hands-on enough
4. Science concept delivery	- not sure if the students followed the scientific concept
5. Equipment	
- sound equipment	- sound equipment to help to everyone hear the presenters
- props	- balancing clown could be much larger
6. Pre/post visit materials	
- pre visit materials	- prior knowledge of actual science principles for discussion
- post visit materials	- handouts or follow up data to assist with student inquiry
7. Public exhibition	- to come to their community
8. Publicity	- be careful not to elect one school as a favourite

Most answers suggested improvement in 'delivery', this was mentioned 11 times. Included in the 'delivery' category are: delivery techniques (how to communicate with young audience), language (clarity, jargon usage) and speed of delivery. Some examples of participants' comments are presented in Figure 12 below.

"Please explain to all Questacon presenters that repeating back children's answers is poor teaching practise (sic) (boring, pointless). If you must reply add something additional or say it back in other words." (Delivery technique)

Participant #32

"Students have a short attention span and low literacy. Therefore it is important to speak loud, clear, softly and repeat idea/concept." (Delivery technique)

Participant #64

"The presenters must be able to communicate fluently and ably with the children." (Language - clarity)

Participant #52

"Less technical language - maybe still use scientific terms but give a more basic explanation to accompany the use of this language." (Language – jargon usage)

Participant #43

"As we were one of the 1st schools for a new collection of presenters, so probably tried to fit in as much as possible - talked very quickly..." (Speed of delivery)

Participant #28

Figure 12: 'Delivery' comments / improvement for the show

The second improvement category is the 'nature of the show' and was mentioned six times. Included in this category is: spectacularity of the show, music, size of audience, and length of the show.

"Add some circus music at the start of the show."

Participant #4

"It could possibly be 1.5 hours for secondary students with lots of action."

Participant #54

"Found the students to be less interested during the transition phases (when they were setting up new experiments one of the girls spoke). Perhaps they could do mini/quick science demonstration to keep the students attention (this seemed to be when students were restless otherwise it was very beneficial)."

Participant #59

"Use of more spectacular or thought- provoking experiments..."

Participant #62

Figure 13: 'Nature of the show' comments / improvement for the show

The comment from participant #59 quoted in Figure 13 was confusing. The participant suggested a short science show be performed between the two main shows to keep the students' attention. This has always been done and the short science show is called a busk. I do not understand why this participant raised this issue. Unfortunately I cannot clarify further as I do not have any direct contact with the schools.

Suggestions to make the show more 'hands-on' were mentioned six times. Three participants expressed their concern about science concept delivery. Another three participants suggested equipment usage to improve the shows. Three other participants wanted to have pre/post visit materials to be used in class. And finally one participant wanted the circus to come and perform in their local area. Some examples of these comments are provided in Figure 14 below.

"If its advertised as hands on with lots of exciting interaction do that." (Hands-on)

Participant #6

"More hands on activities need to be available." (Hands-on)

Participant #51

"The students were entertained but I don't think they thought much about the science behind the show." (Science concept delivery)

Participant #11

"The children enjoyed the show - not sure if they followed the scientific concept." (Science concept delivery)

Participant #10

"I feel some sound equipment to help everyone hear the presenters would be well worth the effort of setting up, etc."(Equipment)

Participant #34

"Maybe prior knowledge of actual science principles so some preliminary discussion could be held." (Pre visit materials)

Participant #53

"Maybe some handouts or follow up data to assist us with student inquiry." (Post visit materials)

Participant #17

"To have the big van come to our community in order to participate in the follow up activities, etc." (Circus event for public)

Participant #50

Figure 14: Comments / suggestion to improve the show: hands on, science concept delivery, equipment, pre/post visit materials, circus event for public

Regarding the comments about hands-on activities as mentioned in the first and second comments in Figure 14, it is necessary to note that Questacon did not advertise their shows as a hands-on experience. The Questacon brochure described the shows as being 'interactive', this means that there would be interaction with students as the presenters would require some volunteers during the shows. The correspondence never mentioned anything about a 'hands-on science show'. The hands-on nature was mentioned with regards the public exhibitions and teacher workshop but not the science shows.

Summary of the show's evaluation

The majority of the participants (56) commented positively about the shows. Sixty out of sixty-eight participants believed that the students either really enjoyed the show or generally enjoyed it. Satisfaction about the show was expressed by 14 participants, a further 30 participants provided valuable comments or suggestions to improve the shows.

4.3.4 Impact of the show (Questions 8,9,10,11)

Further investigation on the impact of the shows needs to be analysed in order to answer the main research question. This section will present the opinions of the teachers as to what impact the shows have had on their own teaching practice.

Future booking possibility (Question 8)

Response was received from 65 participants for this closed question. The majority (57) stated that they would book the science circus if it were available in the future. The participants' willingness to book the program in the future is an indication of their satisfaction. The summary is available in Table 15.

Table 15: Booking possibility in the future

Would you book the science circus in the future if it were available?	
Yes	57
No	4
Not sure	4
Did not answer	3

Four of the participants were not sure whether they would book the science circus in the future. Although this option was not available, they added their own answers such as: 'maybe', 'not decided yet', and 'probably not every year'. Only four participants claimed that they would not book the science circus again when it was available in the future.

Longer- term outcomes for students (Question 9)

This question was a combined open and closed question. The participants were asked whether they thought the visit had longer-term outcomes for students and they were then asked to explain their answers further in the space provided.

The number of valid responses for this question was relatively high: 65 participants answered the yes/no question with a majority (60) providing further explanation. Only one participant did not answer this question completely. Interestingly there was one participant who stated that the visit *might* have longer-term outcomes for students, even when this option was not available, and provided an explanation as follows:

"One show was quite well done. The students generally remembered the outcomes. The second show was not remembered at all due to language problems."

Participant #52

Two participants did not answer the yes/no question but offered their explanations. One had a more positive impression and the other one had a negative impression. Their explanations are provided in Figure 15.

"I'm not sure yet, I think it was a very positive experience for our students and many also went to the circus on Saturday." (Positive impression)

Participant #55

"It could have, this last show didn't." (Negative impression)

Participant #51

Figure 15: Positive and negative impressions: further explanations

The majority of participants (48) believed that the visit would have longer-term outcomes for students while a smaller number of participants (17) did not think so. The summary details of the participants' answers are provided in Table 16.

Table 16: Summary of answers: longer-term outcomes for students

Longer-term outcomes for students	
Answers	**Frequency**
yes, 3 no explanation	48
no, 3 no explanation	17
no answer, no explanation	1
no answer, provided explanation	1
maybe, provided explanation	1

Among the 48 participants who believed that the visit would have longer-term outcomes for students, only three participants did not explain their answer further. Participants who offered explanations gave rich comments; sometimes they provided more than one answer covering different categories (multiple answers). The responses can be grouped into eight different categories, stating that the science shows: (1) encourage positive attitudes towards science, (2) can be linked with class activity, (3) help to show that science is part of everyday life, (4) help to portray that science can be fun, (5) help students to remember, (6) help to increase science awareness, (7) encourage students to try or explore more at school or home, and (8) help to show that science is practical.

Some participants' explanations can be categorised into more than one category, therefore 58 answers were received from 45 participants who believed that the shows had longer-term outcomes for students and explained their answers. Presented below in Figure 16 are some examples of comments that can be categorised in more than one category.

"An increased awareness (increase science awareness), *enthusiasm towards science."* (Positive attitudes toward science)

Participant #9

"The main purpose at the show for small country school like XX (name removed by author) was to demonstrate that science is fun, entertaining (Science is fun) *& part of normal life."* (Science is part of everyday life)

Participant #31

"Students remember it (Remember)+ *we can use things that happen in it will studying those topics."* (Applied in class)

Participant #58

"The children found from simple themes, science can be unpredictable, exciting and fun. (Science is fun) *Hopefully it will stimulate a life long interest."* (Positive attitudes toward science)

Participant #68

Figure 16: Comments that can be categorised into more than one category

The frequency for each category of the longer-term outcomes is presented in Figure 17.

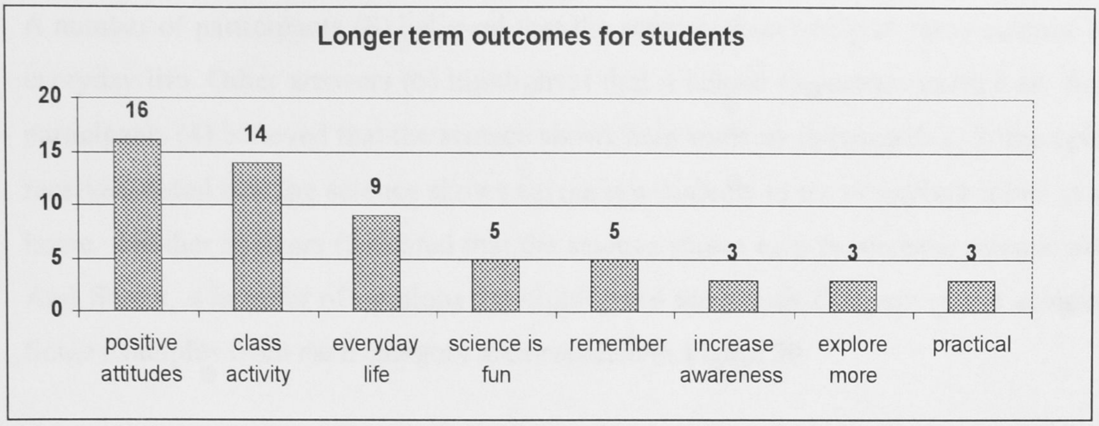

Figure 17: Longer-term outcomes categorisation

The most popular answer was that the science shows encouraged positive attitudes towards science, this was mentioned 16 times. Some examples of the comments are presented in Figure 18.

"The show motivated children in regarding science investigations."

Participant #7

"Students were interested in learning more about things-asking some tough questions!"

Participant #17

"I think it is a great encouragement for students who are enthusiastic about science + for students who don't realise that science is interesting."

Participant #59

Figure 18: Longer-term outcomes – encourage positive attitudes towards science

Many participants (12) mentioned that the science shows can be linked with a class activity and therefore they believed it would have longer-term impact for the students. Some examples for this can be found in Figure 19.

"Relevance to science outcomes according to science and technology syllabus."

Participant #8

"The students were able to apply the information learnt in following science lessons."

Participant #21

"We were able to link to our school based programs - follow up etc."

Participant #49

Figure 19: Longer-term outcomes – applied in class / linked with class activity

A number of participants (8) believed that the science shows help to show science as part of everyday life. Other answers (6) highlighted that it helped to portray science as 'fun'. Some participants (4) believed that the science shows help students to remember. Some opinions (4) received stated that the science shows encourage students to try or explore more at school or home. Another answers (2) stated that the science shows help to increase science awareness. And finally, a number of opinions (3) highlighted the practical aspect of the science shows. Some examples from each category are presented in Figure 20.

"Seeing that 'school' science is actually part of real life." (Everyday life)

Participant #28

"Kids often refer to it, compare things learnt at show with real life." (Everyday life)

Participant #33

"It may make them think about science in a fun way." (Fun)

Participant #27

"Experiments stick in children's minds they will always remember it." (Remember)

Participant #44

"Enthusiastic to have a go at some of the activities at home." (Try more)

Participant #3

"An increased awareness (Awareness), *enthusiasm towards science."* (Positive attitudes toward science)

Participant #9

"Makes them enthusiastic to find out why? Several children did experiments at home and brought what they did to school for show + tell..." (Try more)

Participant #66

"Stimulated interest in science at a very practical level." (Practical)

Participant #53

"Hopefully it has shown students that their ideas and dreams are achievable and that even through an idea sound simple it can be very practical." (Practical)

Participant #63

Figure 20: Longer-term outcomes (everyday life, fun, remember, awareness, try more, practical)

No longer-term outcomes

About a quarter of the participants (17) did not think that the visit had longer-term outcomes because they do not think that the students would actually learn something from it and they claim that the science shows do not fit in with scope and sequence at school

The majority of answers received (8) explaining why the visit had no longer-term impacts stated that the students would not learn anything from the science shows. Some of the participants' comments are provided in Figure 21.

"I don't think children would recall anything from it if I asked them do (sic). Nothing stood out as exciting."
Participant #26
"Could only remember activities not what was to be learned from them."
Participant #29
"Even though students thoroughly enjoyed show, I doubt students would remember outcomes as information presented only cool experiments."
Participant #30
"I don't think the science principles necessarily get through and are retained by the students."
Participant #34
"...Students did not see the real potential of the presenters to inspire them."
Participant #62

Figure 21: No longer-term outcomes - students wouldn't learn anything from the show

Other answers received (7) reasoned that the science shows do not fit in with scope and sequence at school. Some examples are shown in Figure 22.

"Not really linked to our current scope and sequences."

Participant #19

"The show wasn't aimed at what we teach in science + technology."

Participant #20

"While I think the show was informative, it is hard to link these concepts + ideas into our existing science topics within our scope + sequence..."

Participant #43

Figure 22: No longer-term outcomes – does not fit scope and sequence

Follow up activity in class (Question 10)

This question asked whether the participants did or would do any follow up activities for the students after the science circus visit. This is a semi-open question where the participant needed to answer yes/no then they were provided with a space to explain their answer. All participants answered the yes/no question. Almost three quarters of participants (48) claimed that they did or would do some follow up activities.

There were 20 participants who claimed that no follow up activity had been or would be done. Interestingly, among them there were four participants (4) who actually did / would do a follow up activity although they answered no. I present the answers in Figure 23.

"It was a busy time + the class was engrossed in units we were already covering, trying to complete the terms work. I didn't incorporate the show as I didn't know beforehand the content to expect but we did ***discuss*** *the science afterwards."*

Participant #11

"Kinder - too young for anything other than ***oral discussion****."*

Participant #13

"Not as yet – ***will be*** *in with a unit in this term (2) and next term."*

Participant #24

"Reference ***will be*** *made to it when discussing liquids and gasses."*

Participant #57

Figure 23: Participants who said no follow up activity had been or would be done but actually did or would do some follow up

From the participants who answered yes to this question (48) only four did not provide further explanations. I categorised the follow up activities into: (1) discussion, (2) written report, (3) repeat the experiments, (4) oral report, (5) integrated in class activity, (6) will integrate in class activity.

Some participants mentioned more than one follow-up activity, so the frequency presented in the bar chart is based on multiple responses. A total of 58 answers were received and can be found in Figure 24.

"The children discussed it (Discussion) *& wrote some report."* (Written report)

Participant 48

"Discussion (Discussion) *& also continual reference in class."* (Applied in class)

Participant #35

"... Tried balancing point. (Repeat the experiment) *Write a report... "* (Written report)

Participant #38

Figure 24: Follow up activity – multiple answers

Discussion was the most common (24) follow up activity. Quite a number of answers (11) stated that the participant would integrate things from the science show into a class activity somehow. Written reports were also quite popular (9) follow up activities. The written reports were written for class work and some other reports were written for media such as the school newsletter and community news. Some answers (6) mentioned that they had already integrated the show into their class activity somehow. Some others (6) repeated the experiments and a couple mentioned oral reports as their follow up activity. Some examples of the participants' comments are provided in Figure 25.

"Discuss activities in class as compared with the ones that they observed." (Discussion)

Participant #60

"We discussed what the students saw at the show - what they liked or did not like, what was their favourite part, etc." (Discussion)

Participant #61

"As I come to these topics in science I will refer back to them." (Will integrate in class activity)

Participant #54

"...[Students] write a report for the newsletter which is distributed to 70 families in our community." (Written report)

Participant #38

"Students in 4-6 wrote up a report for the school newsletter..." (Written report)

Participant #50

"Our program this term is based on your publications. Many thanks!" (Integrated in class)

Participant #40

"We had a whole school unit on "communication" and did a session each day (the student's rotated activities) on the science of sound." (Integrated in class)

Participant #55

"... We did use some experiments in class." (Integrated in class)

Participant #25

"Verbal reports for class members not attending. The reporters used their experience to explain the phenomena they saw." (Oral report)

Participant #28

Figure 25: Follow up activity

Only 20 participants claimed that they did not or would not do any follow up activities, 13 of them provided further explanations / reasons and four of them actually did/would some kind of follow up activities as explained above in Figure 25. I categorised the participants' explanations/reasons as: (1) scope and sequence limitation, (2) the participant was not the science teacher in the class level they accompanied to the show, (3) other reasons. The frequency of each opinion is presented in Table 17.

Table 17: Categorisation of reasons for no follow up activity

Reasons for no follow up	Frequency
Scope and sequence	7
Not science teacher	4
Other reasons	2

Scope and sequence limitation was the most popular reason mentioned seven times. Other four participants mentioned that they were not the science teacher for the class they accompanied to the shows. Two other participants had other reasons; one reasoned that not all of the children enjoyed the show and another participant provided a rather unclear answer. Some examples are presented in Figure 18.

"No because our school scope + sequence wasn't focused on the experiments shown." (Scope and sequence limitation)
Participant #20
"If I was teaching year 8 science then I would most definitely have a follow up lesson." (Not the science teacher)
Participant #59
"When a show/visit is enjoyed by children they talk about it for a long time after. The children never said a word about it." (Others – student did not enjoy the show)
Participant #26
"At this point follow up has not been done. This would be an excellent way of reinforcing the science presented and help with the situation discussed above [I don't think the science principles necessarily get through and are retained by the students]." (Others – unclear)
Participant #34

Table 18: No follow up activity

Teaching influence (Question 11)

This question asked the participant whether the science circus visit influenced their teaching practice in any way. All but one participant answered this question. The responses received were almost equal, 33 participants answered yes and 34 participants answered no.

Interestingly from 34 participants who answered 'no', one claimed that his/her teaching practice had been influenced by a teacher workshop.

"Not the show particularly but it was definitely influenced by teacher workshop."

Participant #30

Some other participants also mentioned the teacher workshop and they claimed that their teaching practice has been influenced. I will discuss the teacher workshop in Chapter 5.

Table 19: Visitation influence on teaching practice

Has the science circus visit influenced your teaching practices?	
Yes	33
No	34
No answer	1

All participants who believe that the science circus visit has influenced their teaching practices provided further explanation. I categorised the answers as follows. The visit influenced their teaching practices in that the participants: (1) think more creatively, (2) were influenced by the teacher workshop (3) incorporate more hands-on activity, (4) are more confident in teaching, (5) use more practical approach, and (6) are able to relate science to everyday life.

Some participants provided more than one answer resulting in multiple categorisations. Examples of answers that result in multiple categorisations can be found in Figure 26. Frequency of each category can be found in Figure 27.

"*To help students have fun* (Fun) *with science at a hands on level.*" (Hands-on)

Participant #39

"*Science is fun* (Fun) *and easy to do. Just be a little creative* (Think more creatively) *and adventurers.*"

Participant #60

"*Try + use more simple demonstrations* (Think more creative) *to make science more fun* (Fun) *and relevant.*"

Participant #67

Figure 26: Teaching influence – multiple categorisations

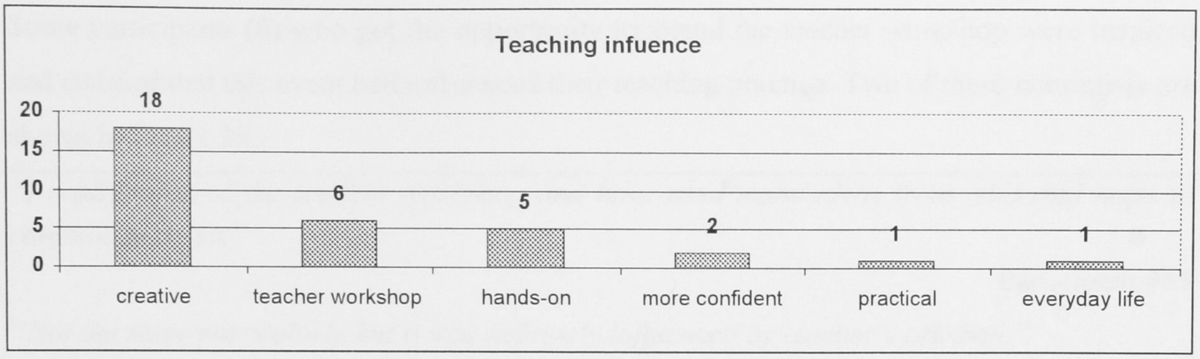

Figure 27: Frequency of categories of ways teaching practice has been influenced

The bar chart in Figure 27 shows that the majority of answers (18) received from the participants stated that the visit has helped them to think more creatively. Some examples of the participants' comments are provided in Figure 28.

> *"Teachers were equally amazed at how easy some of the experiments were + fired us up to think outside the square when developing units."*
>
> Participant #12
>
> *"Lots of ways of gaining children attention/motivation."*
>
> Participant #13
>
> *"... Just be a little creative and adventurous."*
>
> Participant #60

Figure 28: Teaching influence – creative thinking

Among those who claimed that the visit helped them to think more creatively, there were six participants who also mentioned a fun factor in their answers. Examples of these answers are presented in Figure 29.

> *"I am able to find easy and fun experiments to do with my students."*
>
> Participant #21
>
> *"It has shown me that there are some great, fun activities to do."*
>
> Participant #23
>
> *"Now [I] pretend to be a character when teaching science!"*
>
> Participant #37

Figure 29: Teaching influence: more creative – fun

Some participants (6) who got the opportunity to attend the teacher workshop were inspired and claimed that this event had influenced their teaching practice. Two of these comments are shown in Figure 30.

"I really enjoyed the teacher workshop and have used many ideas from (sic) and hope to continue to do so."

Participant #55

"Not the show particularly but it was definitely influenced by teacher workshop."

Participant #30

Figure 30: Teaching influence – teacher workshop

Another group of participants (5) claimed that after the visit they incorporated more hands-on activities into their teaching practices. A few more (2) answered that the visit had made them more confident in teaching, helped them to use a more practical approach (1) and showed that science is part of everyday life (1). Some examples that represent each category can be found Figure 31.

"More hands on science..." (Hands-on)

Participant #49

"Hands on activities, especially for younger children, makes their natural curiosity part of their learning in a satisfying way." (Hands-on)

Participant #68

"I have aimed for a more practical manner of teaching." (More practical)

Participant #33

"It has made me more confident/able to do more science activities in the classroom. Seeing the students so engaged in the activities has made me more willing to do science." (More confident)

Participant #61

"Have a go. Science is in every day life - be aware of it." (Everyday life)

Participant #45

Figure 31: Teaching influence (hands-on, more practical, more confident, everyday life)

There were 33 participants who claimed that the visit had not influenced their teaching practice. Many participants (22) did not provide any explanation. From the few participants who explained further, I have categorised their explanations: (1) their teaching practice was already hands-on, (2) the participant was not the science teacher for the class they accompanied to the shows, (3) curriculum limitation, and (4) others. Table 20 below shows the frequency for each option.

Table 20: No influence to teaching practice categorisation

Categorisation	Frequency
Already hands-on	4
Not the science teacher	2
Scope and sequence limitation	1
Lazy	1
Need more support from Questacon	1
I would like it to be	1
No info	22

The majority of participants (4) believed that their teaching practice is already hands-on and there is therefore no need to change. Two of the participants claimed that they were not the science teacher for the class they accompanied to the shows. One participant argued that the curriculum limited them in science teaching practice. In the 'Other' category one participant required more materials from Questacon, one simple and honest answer from one participant claimed they were lazy and one participant provided an unclear answer. Some examples of the participants' answers are presented in Figure 32.

"Most science I teach is hands on." (Already hands-on)

Participant #8

"Use some of the demonstrations already (been teaching many years so probably have absorbed the good bits that are possible in labs already)." (Already hands-on)

Participant #28

"I don't teach this class level." (Not the science teacher)

Participant #34

"Have set units of work to complete in science." (Curriculum limitation)

Participant #3

"It is great to see experiments and hands on but it would have been helpful to have note..." (Other- need more support)

Participant #50

"I'm lazy."(Other –lazy)

Participant #20

"I would like it to be." (Other – not clear)

Participant #47

Figure 32: Teaching practice – not influenced

4.3.5 Any other comments (Question 13)

This question provided participants with a last opportunity to comment about anything that had not been covered already in the questionnaire. The majority of participants (34) provided positive comments as can be seen in Table 21.

Table 21: Other comments: categorisation

Any other comments	
Positive comments	34
Less positive comments	7
No comments	27

The majority of participants (22) expressed their satisfaction in various words, such as: great, excellent shows, thank you for coming, and so on. Some examples are available from Figure 33 below.

"The Science circus is great for country kids."   Participant #1   *"Thank you for exposing the children for science in an interesting idea." (sic)*   Participant #19   *"Always great to have real live science shows in schools. Not just the same old teachers."*   Participant #28   *"Thank you for a wonderful & interesting show."*   Participant #46

Figure 33: General comments – satisfaction comments

Only seven participants expressed their disappointment and/or provided less positive comments. It is important to focus our attention on constructive comments so improvements can be made in the future. The participants commented on (1) presenters, (2) circus accessibility, (3) publicity, and (4) about the show.

Two comments about the presenters were received. Publications in a local newspaper were mentioned twice. Two comments were received about the hands-on nature of the show. One of the participants compared the science circus with another travelling exhibition and another participant felt that the show was not as hands-on as it was supposed to be. Finally, one participant commented about the circus accessibility and expressed their concern about the travelling distance for students to come to the circus. Some examples of their comments are available in Figure 34.

"Please make sure the presenters can speak clearly and at children's level of understanding." (Presenter)

Participant #51

"The presenters needed more experience in keeping the attention of large groups of children also questioning + answering levels of understanding of the audience." (Presenter)

Participant #11

"We recently had a maths show visit our school, where children were allowed to touch/feel, interact." (Hands-on)

Participant #26

"I felt it was false publicity. [we publicised it as 'hands on' not a 'show'] " (Hands-on)

Participant #6

"Disappointing to read the letter from Questacon in local paper nominating one school as a favourite- this can be very detrimental to the reputations of the other schools or detract from Questacon!" (Publicity)

Participant #42

"I was very disappointed to see a letter in our local paper from one of your demonstrators who visited our area. This letter was very positive, however the demonstrator named a specific school as being "their favourite school". I felt that this was unprofessional and inappropriate, as I don't appreciate the fact that one school was singled out. This was the general feeling of several teachers who I spoke to." (Publicity)

Participant #43

"No children attended the travelling exhibitions-too far away (60 kms). Many attended (@30) when closer (30 km) in 2004." (Circus accessibility)

Participant #31

Figure 34: General comments – less positive comments

The third comment by participant #26 compared the science circus with a maths show. This was a different situation as the 'Questacon Maths Squad' referred to is in fact a small exhibition-style outreach program. The Questacon Maths Squad was designed as a hands-on event and allows students to play with a number of puzzles and exhibits.

The fourth comment about the hands-on nature of the show (participant #6) was not appropriate as the science circus never advertised the science shows as being hands-on.

4.4 CONCLUSION

A total of 68 valid questionnaires were returned. The majority of respondents were primary school teachers. Overall, the results have been positive. Discussion about how the results help to answer the research question will be presented in Chapter 5.

Chapter 5 Discussion and Conclusion

The science shows alone are an important part of this research, therefore section 5.1 and 5.2 in this chapter are dedicated to discussing the value of the shows and then how to improve the shows. This chapter also discusses the results of this study in order to answer the research questions. Each question is addressed individually.

5.1 VALUE OF THE SHOWS

The majority of respondents were primary school teachers who were already familiar with the science circus. I judged the familiarity of the participants with the science circus by their response to Question 4, which asked if they had booked the science circus before. Thirty-seven participants indicated that they had booked the circus before.

The results revealed that the majority of participants considered the science shows to be a good and valuable program.

Fifty out of sixty-eight participants could remember and name at least one show that they watched. It was important to check whether the participants were able to remember the show they had watched after two months. The majority of comments received from the participants who remembered the shows were positive, suggesting they remembered shows because they liked them. The high proportion of participants that could name a show indicates that the shows were good enough to be able to 'stay' in participants' memories.

It would have been easier for the participants if I had listed the names of the shows and provided a brief description of each show and then asked the participants to choose which shows they saw. However, this approach would diminish the original aim of asking this question in the first place (i.e. how well they could remember the shows two months after the visit), so I decided to use an open question instead of a closed question.

It would help the teachers to remember the shows if the science circus presenters mentioned the show's title and provided a brief description about the show before they started to perform. This would provide a better understanding about the show and its science content.

The 'Liquid nitrogen' show was the show most frequently mentioned by the participants. This may have happened for several reasons. The liquid nitrogen show has always been one of the more popular shows and so there are more science circus members who have mastered this show than others. On this tour there were three science circus members who had mastered this show compared to only one or two members who had mastered the other shows. Therefore it was probable that more participants would have seen this show compared to other shows. This show may, however, be more memorable than other shows in its own right. It is an exciting show with lots of bangs and the added 'danger' of using liquid nitrogen and these factors may have helped it to stick in the memories of the participants better than other shows.

The 'Collision' show was the second most frequently mentioned show. Again, this show is known to be a more popular show so there were also three members of the science circus who had mastered it.

Unfortunately, there was no record of which shows were performed on the particular trip observed. The only information available was which science circus members had mastered which shows. Because of that, comparison between the data gathered and the actual frequency of the shows cannot be made.

The majority of participants (82%) commented positively about the shows. The comments covered a wide range of themes. The majority of participants reported that the science circus' show was a good performance. From the results of my study, there are three important aspects that contribute to a show's success: audience, presenter, and the interaction between presenter and audience. All the positive comments received from the participants about the shows address those three factors. From this we learn that good presenters are able to design the show to suit the audience level of understanding. They are able to encourage audience participation through interactive performance and therefore are able to hold the attention of the audience. A good science show is able to demonstrate the practical aspect of science in various interesting performances as well as being informative.

The science circus' aim to entertain and provide enjoyment for the audience was achieved as 60 out of 68 participants thought that the students had really enjoyed or generally enjoyed the shows. Enjoyment is one aspect in the vowel analogy (AEIOU) that represents the 'E' letter, which Burns (2003) used for the evaluation of the science shows.

5.2 Improvement of the shows

I provided an opportunity for the participants to add comments or suggestions on how to improve the shows they had watched. Thirty participants offered their suggestions in response to this question. Some other participants provided their suggestions in response to other questions. A list of factors needing to be improved is provided in Table 14 in Chapter 4.

Some of the improvements suggested by participants are possible to accomplish while some are impractical. It is also important to note the limitation of this study that was already mentioned in Chapter 1: the trip evaluated was the first trip for all the science circus members so it might not represent their best performance of the year.

1. **Delivery**

   There were a few comments about the language use not being appropriate for the students' level of understanding. Science circus members are trained to deliver the show's concepts to match the audience's level of understanding in a clear language and with minimal use of jargon. Improvement in this area is important and achievable.

   Regarding the problem with language clarity, I want to make it clear that there was only one science circus member with a non-english-language background. From the evaluation, only two participants mentioned this language problem and both participants came from the same school. The presenter with the non-english background also performed in other schools and there were no comments or complaints received from these schools. However, there is a possibility that the other schools visited by this presenter did not respond to this survey.

2. **The nature of the shows.**

One participant suggested that the science show should use more spectacular experiments (participant #62). This participant taught years 7-12. This finding is similar to those made by Barbagallo (1997) who found that teachers in secondary levels prefer more spectacular experiments that cannot be done by them in the school. This participant watched the 'Collision' and 'Balancing' shows. For this participant the 'Liquid Nitrogen' show would probably have been more satisfying. Unfortunately the school cannot ask for certain shows to be performed, as has been explained in Chapter 2.

Regarding the audience size, it was explained in the school booking application that one session can hold up to 120 students, depending of the capacity of the school's show venue. Sometimes a school has more than 120 students and all of them want to see the science show. If the time and schedule permits then the shows can be split into two sessions. However, sometimes it is impossible to do so because of the tightness of the schedule. In this case, the booking officer would contact the school to arrange the best solution. If the school has a big enough venue for all the students then the show will run with a larger audience size. This is when some problems arise because for example, the audience cannot hear or see the show properly.

The suggestion to increase the show time to 1.5 hours is currently impractical as the science circus has a very tight schedule due to limited resources.

The addition of circus music at the beginning of the session might be possible if each group of science circus members can bring a small audio player for this purpose. However, if this were done badly it would not create the atmosphere wanted and would have a negative effect.

3. **Hands-on**

Some participants commented that there were not as many hands-on activities as advertised. Questacon never promoted the shows as being 'hands-on'. In the publication materials sent to schools, the shows were advertised as 'interactive'. Interactive here means student participation as volunteers in the shows. For some people it may imply that the students would have opportunities to interact with hands-on exhibits, however Questacon did not intend this meaning.

A possible explanation for this was that the participants were remembering the advertisement for other components of the science circus: the public exhibition and the teachers' Professional Development workshop, which were both advertised as hands-on experiences.

Another possibility is that the participants already had a preconception in their mind and assumed that everything related to Questacon involves a 'hands-on' experience. It would be interesting in the future to look into the preconceptions of teachers and other clients with regard to Questacon events.

4. **Science concept delivery**

A few participants commented that they were not sure whether the students followed the scientific concepts presented. In its booking information for in-school performances (Appendix C), it was stated that the science circus experience was designed to motivate and challenge students to explore science and technology for themselves. Therefore the shows aimed to spark interest in science and technology in the hope that once the students are interested in science, they will be fuelled to explore and discover more about science by themselves.

The fact that the students had not followed scientific concepts in the first place did not mean that the students did not learn something. Stocklmayer & Gilbert (2002) argue that visitors to science centres may not grasp science concepts on their first visit. However, in the future the visitors might see something that triggers memory about their experience in the science centres and be able to link them and have a better understanding about such concepts. This phenomenon can happen several times and each time the visitors encounter it again, they would readjust their science concept according to the situation. A similar situation can be argued for the science shows. The students might not grasp the science concept the first time. However, it may help them to remember and it is expected that in the future when the students find related issues in their everyday lives or in the classroom, they would be able to connect their science show experience with relevant science concepts.

5. **Equipment**

There was a suggestion that the presenters should use audio equipment to help the audience hear the show better. All science circus members are trained to project their voices when they perform. However, sometimes the design of the venue (echo or bad acoustics) or larger audience size made it difficult for the performers to project their voices for everyone to hear. So the audio equipment was a good idea, although in practice if the equipment were quite large, some problems in transporting such equipment everywhere may arise. For example when the science circus members need to travel by air, size and weight are very important considerations. If the schools visited have large halls then there is a possibility that the schools may have their own audio systems. In this case the science circus member would only need to bring a radio microphone.

The other suggestion was to make the demonstration props larger so all of the audience can see it. A participant gave an example of the balancing clown, saying it should be larger. This was a good idea because it is important for Questacon to design its props large enough for the audience to see.

6. **Pre/post visit materials**

Suggestions for pre-visit materials are impractical. As mentioned in the booking process information, when a school books the science show events, Questacon sends them a brief list and explanation of each show available although there are no guarantees as to which shows would be performed. So 'who goes where' is not decided until the first week of travel. As explained before in Chapter 2 (section 2.9.3.1), each science circus member has mastered two shows and they are free to choose which shows they perform in particular schools. Often, the science circus members would decide which shows to perform after they arrived in schools. Their decision depends on which shows will suit the audience better. Considering this circumstances, it is impractical for Questacon to provide pre-visit materials for schools.

Post visit materials are already available and given to teachers after the shows. The post visit materials are also available on-line from the Questacon website. Links to the national curriculum are available in the post visit materials.

7. Public exhibition

Some participants complained that the public exhibition event did not come to their community and they would like it to do so next time. However, this problem cannot be easily solved. Wherever the science circus opens their public exhibition there will always be an area that would not be visited and would feel disappointed. Unless the science circus has more resources that enable them to visit every place, this suggestion would be impractical.

8. Publicity

The science circus sent a form for each school to fill in indicating their willingness to accept a visit from journalists. If the school had no problem, the science circus would make a list of the names of all the schools that were willing to receive the local press and a photographer to cover the science circus event in their school. The list would be distributed to the local journalists and the journalist could choose to come to the schools they liked.

However, Questacon needs to be cautious about some aspect of publicity. In this study, I received two complaints from participants who teach in certain areas. Those teachers were upset because a Questacon science circus member was quoted in a newspaper article as having elected one school as their favourite. This really offends other schools.

Although the majority of participants felt that the shows were good, improvements have been suggested and so it is necessary and important for Questacon to pursue them.

5.3 Question 1: Do the science shows performed by the science circus in schools affect teachers' classroom practice in any aspect?

5.3.1 Longer-term outcomes for students

Yes, there are longer- term outcomes!

There were 48 participants who thought that the shows had longer-term outcomes for students. They were given space to explain their answer further. I mentioned earlier that there were eight categorisations for this answer that can be seen in Figure 17 in Chapter 4. All answers mentioned below support the AEIOU vowel analogy that Burns (2003) used to measure the effectiveness of science shows.

1. **Encourage positive attitudes toward science.**

   Participants mentioned this factor most frequently (16 times). Ryder (2001 p.4) stated that science in school is the beginning of a learning process which leads to engagement with science as an adult. He states that:

   > "...it is important that school science promotes a positive attitude towards engaging with science..."

   Encouraging positive attitudes toward science can be considered to represent 'Opinion' in the vowel analogy (AEIOU) that Burns (2003) used to measure the effectiveness of science shows.

2. **Can be linked with class activity**

   Many participants thought that the science shows had longer-term outcomes because they can be linked with class activities. Incorporating the science shows into class activities can help to demonstrate the science concepts behind the shows. To help teachers do this, post-visit materials are available online from the Questacon website and links to the national curriculum for each show are provided.

   Bryant (2001) stated that even though the duty of a science centre is not necessarily to 'educate' the public, education can be achieved by specific organisation, for example linking displays to the curriculum. The science circus, as part of the science centre, can do the same thing by linking the show to the curriculum. By linking the science shows to the formal curriculum, the shows fulfil the 'Understanding' function in the AEIOU vowel analogy (Burns, 2003).

3. **Help to show that science is part of everyday life**

   It is important to show the students that science is part of everyday life. Research shows that students' interest in science learning has been decreasing partly because students cannot see the relevance between science and their life (Rennie *et al.*, 2001; Prayekti, 2004; Taufik, 2004). It is also stated in the New South Wales curriculum for K-6 levels that students are expected to apply their science understanding to everyday life (Board of Studies New South Wales, 1998).

   The idea that the science shows help to illustrate the relevance of science and make connection to everyday life is part of the 'Awareness' factor in the AEIOU used to measure the effectiveness of the science shows (Burns, 2003).

4. **Help to portray that science can be fun**

   A fun factor in learning is considered to be part of an ideal picture of the quality teaching and learning of science in Australia (Rennie, 2001). As described by Bryant (2001) the science shows are not designed to be purely educational, they are primarily a performance intended to bring fun to the arena of science. The science shows use this aspect of fun to engage the audience. Student interest and enjoyment in studying is linked to this idea. It is anticipated that students will have more interest in science learning in the future if they associate science with fun and entertainment after seeing a Questacon science circus show.

   Burns (2003) also acknowledged the 'Enjoyment' factor in the AEIOU method to measure the effectiveness of the science shows.

5. **Help students to remember**

   Each show presents a specific topic in a series of 'tricks' that bring amusement and astonishment (Bryant, 2001). Such a performance sticks in the minds of the students who watch it, therefore helping them to remember the ideas that were covered. I think it is fair to argue that people tend to remember something that they find wonderful. However, the final aim is not necessarily to help the students remember everything in the show. In the future when the students come across something related to the show, it will trigger a memory and help the student see the relevance and understand the subject better (Stocklmayer & Gilbert, 2002). Therefore, it would contribute to the 'Understanding' factor as mentioned in the AEIOU method (Burns, 2003).

6. **Help to increase science awareness**

   Science and technology are important contributors to the socio-economic development of nations (Tan & Subraniam, 2003; Iaccarino, 2004) and therefore the public awareness of science is desirable (Durant, Evans, and Thomas, 1989; Sjøberg, 2001; Rennie *et al.*, 2001). One of Questacon's stated aims is to increase science awareness in Australia (Australian Government, 2003-2004) and the science circus as part of Questacon has the same mission. 'Awareness' of science is clearly recognised as the first factor in evaluating the effectiveness of the science shows in the AEIOU vowel analogy (Burns, 2003).

7. **Encourage students to try or explore more at school or home**

   This follows on from point 1 as it can be seen as a result of developing a more positive attitude towards science. The aim of the science circus' show was to make the audience comfortable with simple science (Bryant, 2001). Because the experiments and the materials are simple, they encourage the students to try it themselves and explore more at school and at home. Drawing 'Interest' in science is another factor acknowledged in Burns' (2003) AEIOU vowel analogy.

8. **Help to show that science is practical.**

   Rennie (2001) explains that practical work is an essential component of the science curriculum. Therefore it is desirable that the science shows help to show that science is practical. Therefore the science shows helped to change 'Opinion' or attitudes that are also represented in the AEIOU vowel analogy (Burns, 2003).

No, there are no longer- term outcomes!

Twenty-five percent of participants thought that the science circus visit had no longer-term outcomes for students. The majority of this group of participants explained that they do not think that the students would learn anything from the show, as it only demonstrated 'cool experiments'. Some others claimed that the science shows do not fit in with the scope and sequence of their curriculum.

Bryant (2001 p.252) argues: "the show is a show first and foremost and only secondarily is it an educational experience."

If we consider the three aspects of learning (cognitive, affective and psychomotor) identified by Benjamin Bloom (Wellington, 1990; Falk & Dierking, 1992) and previously discussed in Chapter 2, it can be seen that the science shows focus mostly on providing an affective aspect for the audience. In other words the shows function to promote a change in attitude, belief and feeling about science. Unfortunately, cognitive aspects have traditionally been the focus of learning (Falk & Dierking, 1992). Some participants still believe firmly that this aspect is the most important. This may have resulted in the feeling that the students did not learn anything from the science circus visit if they did not learn any science concepts. This focus on the cognitive aspects of learning is by no means the fault of the teachers. The science curriculum is too crowded and dominated by content, and so forces the teachers to concentrate on the cognitive aspects in order to prepare the students for assessment by test and exam (Rennie, 2001).

Longer-term outcomes do not have to be educational. As mentioned by other participants above, the impact can be simple: entertain the students or show the relevance of science to everyday life. Such things may not show obvious or direct results but may have positive effects in the longer term during the student's life.

5.3.2 Follow up activity

Nearly three-quarters of the participants (48) did or would do a follow up activity. This finding is consistent with what Rennie (2000) found in her evaluation of the educational effectiveness of the Shell Questacon Science Circus program.

Some teachers had not done a follow up activity but indicated that they would do so even though the questionnaires were not distributed until two months after the science circus had visited the schools. Although two months may seem a long time to leave before doing a follow up to the science show the teachers explained that the class had not yet covered the topics related to the science show but were willing to do the follow up activity once they reached the topics.

A number of participants indicated that the class had produced written reports as their follow up activity. It is interesting to note that some reports were not only written for the class work but also for a bigger audience (school newspaper) and even for the community (newsletter which was distributed to 70 families in the community). In smaller regions, the visit by Questacon was a 'big thing'. Bryant (2001) explained that many people who live in the outback have no opportunity to visit Canberra, thus welcome the science circus with open arms into their community.

Of the rest of the participants who did not or would not do any follow up activity the majority reasoned that the scope and sequence of their curriculum limited them from doing so. I found this a reasonable answer; Rennie (2001) found that the teachers felt that they do not have enough time to cover all science content.

5.3.3 Affecting teaching practice?

The responses received for this question were almost equal with only one participant not answering the question. There were 34 participants who said that their teaching practice had been influenced by the science circus visit and 33 claimed that it had not.

Yes, it affects me!

1. **Creative and fun**

   Of the participants who stated that their teaching practice had been influenced, the majority (18) explained that the visit had helped them to think more creatively. Interestingly one-third of the participants in this group (6) also mentioned the fun factor. This indicates that the teachers understand that science is not just about the concept and content but that it is important to take the fun factor into account. This affective aspect of learning was outlined in the previous section about 'longer-term outcomes for students'.

2. Hands-on aspect

Falk and Dierking (1992) stated that many educators use Benjamin Bloom's taxonomy of educational objectives, in which the psychomotor (muscular skill, body coordination) is the third aspect of learning. I think the 'hands-on' concept is a good example of learning that involves the psychomotor aspect because usually it requires participants to interact physically with the exhibits.

Rennie *et al.* (2001) also mentioned in the ideal picture of science teaching and learning that 'hands-on' was one of the crucial components of the science curriculum. Some participants (5) admitted that they now used a more 'hands-on' approach because they had been influenced by the science circus visit.

3. Professional Development teachers' workshop

The Professional Development teachers' workshop is something that needs to be discussed in this thesis. Although the workshop was not the focus of this study, some participants mentioned the value of this program and how it affects their teaching practice. There were six participants who claimed that the teacher workshop had influenced their teaching practice. In addition there was another participant who answered 'no' to the question but claimed the teacher workshop, rather than the show, had influenced their teaching practice.

Rennie *et al.* (2001) mentioned that development programs for teachers are one of the most important factors that would support quality teaching and learning in science. Teaching science is a profession that needs on-going professional development. Employers need to support and facilitate this.

It is good that Questacon can facilitate a Professional Development teacher workshop through the science circus. The fact that the workshop travels with the circus means that the program benefits more teachers especially in regional Australia. Positive comments received from participants show that the science circus has done a good job. It would be useful to analyse the teacher workshops further and evaluate their impact on teaching practice.

4. **More confidence in teaching**

Two participants stated that the visit had helped them to feel more confident in their teaching abilities. The participants who claimed this were teaching K/1 level. This is an important point to take into account, especially for primary teachers. Many primary teachers lack backgrounds in science therefore it is difficult for them to teach science. Rennie *et al.* (2001) conducted a telephone interview with the teachers and confirmed that teachers' lack of science background was one of the most frequently mentioned factors limiting quality science teaching and learning practice.

5. **Practical aspect and part of everyday life**

These two aspects have been discussed in the previous section about longer-term outcomes for students. It is worthy of note that not only do the teachers think that the students have gained a better understanding of the link between science and everyday life but that it has helped the teachers themselves think about science in a more practical way and connect it to everyday life.

No influence

Of the 33 participants who claimed that the visits had not influenced their teaching practice in anyway, only 11 explained their answers. The majority (4) felt that their teaching practice had already been hands-on and therefore the visit had not necessarily changed their teaching practice. Unfortunately, further confirmation of these answers by contacting the participants was not possible. It would beneficial to investigate the hands-on teaching practices that are already implemented by these teachers.

An interesting answer was received from one participant who admitted honestly that he/she was too lazy to change teaching practice. I found from this participant's previous answers that he/she thought that the show was great but also thought that the visit had no longer-term outcomes because of scope and sequence limitations. Although the answer to this question sounds as if it may not be serious, it can be seen as an expression of how the participant felt about the heavy content of the science curriculum and how little time is available to prepare or teach science properly. This made me think about whether this is indicative of other respondents who were not so 'open' in their response.

5.4 Question 2: Is the current practice of the science circus feasible in Indonesia?

From the literature review, we can see some similarity in science teaching and learning in Australia and Indonesia.

5.4.1 Science curriculum and its problems

The minimal science curriculum content is determined nationally in both countries. In Australia, each state government outlines the details of the curriculum. In Indonesia the city or district government coordinates and supervises the elementary level's curriculum and the province government does the same thing for the secondary level (*Undang-undang Republik Indonesia nomor 20 tahun 2003 tentang Sistem Pendidikan Nasional*, article 38, 2003)

Both countries actually have good science curricula with some similarities. For example, science teaching and learning aims to show the relevance of science to everyday life and science subjects should be taught in an interesting way to draw students into science. Unfortunately what is actually implemented in the classroom does not necessarily reflect the content of these good curricula.

Both countries face similar problems in science teaching and learning. Science subjects tend to be taught using teacher-centred methods with focus on the science content. The evaluation system (final test) usually forces teachers to teach science using these traditional methods. The result of this situation is that students dislike the science subjects because they cannot see the relevance of science to their everyday lives. Ultimately, the students tend to avoid the science subjects when they are no longer compulsory, causing a decrease in the number of students who are taking science subjects at the higher levels of education.

5.4.2 Science centres and travelling science centres

Science centres complement formal science education with their informal learning roles. Science centres provide ideal environments for visitors to interact with science in a fun way.

Australia has a national science centre – Questacon located in Canberra, the capital city of Australia. Indonesia has only one science centre – *PPIPTEK* located in Jakarta, the capital city of Indonesia. Those science centres together with many other science centres in the world, attempt to popularise science in an informal, and interesting way.

Sometimes access to science centres is limited by location and time. People who live in areas that are far from where the science centre is located might find it difficult to access the science centre. Questacon realises that Australia has a very large area and dispersed population. In order to provide a wider opportunity for everyone to experience science, Questacon designed a science circus program that travels all over Australia. During the trip the science circus visits the schools to perform science shows, provides a Professional Development teacher workshop and also conducts a public exhibition that is open to the public and provides a 'hands-on' science experience.

PPIPTEK has not yet developed a travelling program in Indonesia. Indonesia is similar to Australia in that it also has a large land area with a dispersed population. The only difference is that Indonesia is not just one massive land mass but consists of five big main islands and many other smaller islands. Many people have a similar problem to that experienced by people in Australia in accessing the science centre in Jakarta. Having a similar program to the science circus in Australia would help to provide wider opportunities for Indonesians to experience science. The science shows would be especially valuable in that they would provide Indonesians with a different way to experience science.

5.4.3 Evaluation of the science circus

This research aimed to evaluate the effect of the science shows on teachers' teaching practice. Although the study was done on a small scale, there is a variety of evidence supporting the idea that the results are generally encouraging for Questacon. The teachers thought that the students enjoyed the shows and believed that the shows had longer-term outcomes for the students by, for example, encouraging positive attitudes toward science, helping to show that science is part of everyday life and showing the practical and fun side of science. Bryant (2001) suggests that the science show is one of the science circus' means of bringing about an affective change in the public.

Half of the participants believed that their teaching practice had been influenced by the visit. They claimed that the visit had increased their confidence in teaching science, inspired them to be more creative and fun, encouraged them to integrate more practical and hands-on aspects into their teaching and to relate the science they teach more with everyday life situations.

These results indicate that the science shows are indeed a worthwhile program. The majority of participants stated that they would book the science circus again if it were available in the future and indicated their satisfaction with the programs.

5.4.4 Relevance of the science circus to Indonesia

All of the benefits that this evaluation has shown that the science circus brings to the schools are things that Indonesia needs. The Indonesian education system emphasises the importance of integrating interactive, inspiring, alive, fun, challenging science activities that encourage creativity and responsibility (*Undang-undang Republik Indonesia nomor 20 tahun 2003 tentang Sistem Pendidikan Nasional*, article 37, 2003). Not only is the cognitive aspect of learning recognised, but also the affective aspect is acknowledged to play an important part in learning (*Peraturan Pemerintah*, article 15.19, article 35.19, and article 80.19, 2004).

The science circus provides an affective aspect of learning by integrating fun and excitement with the science facts to engage the audience. I think Indonesian students would also enjoy such a thing if they were given the opportunity to experience science shows.

The science show also helps Australian primary teachers to become more confident in teaching science. The science shows would also be useful for Indonesian primary teachers who lack a science background.

In Indonesia there are still many people who do not have the opportunity to come to the capital city, mainly because they are too poor. Bringing a science circus to Indonesian regions would provide more opportunity for these people.

5.4.5 The challenge

Although the science circus seems to bring many good things, there will be some challenges in implementing such a program in Indonesia. The procedure would be complex, requiring an extensive collaboration of many sectors. Many things need to be done: finding sponsorship, finding scholars who will present the science shows, developing the science show concepts, designing the procedures, and many other complex tasks.

So really, the question is not "how can we do it?" – we can do it with determination and lots of hard work. I rather think the question is "when will we start?" There is a saying, "A palace is not built in one day". This is true, but if we do not start, we will never achieve the goal.

5.5 CONCLUSION AND RECOMMENDATIONS

The purpose of this study was to investigate the impact of the science circus' science shows on teachers' teaching practice. This study also investigated whether the science circus current practice is feasible in Indonesia. These aims were addressed through the following two research questions:

1. Does the science show performed by the science circus in schools affect teachers' classroom practice in any aspect?
2. Is the science circus a feasible model for Indonesia?

5.5.1 Conclusion

This study concludes that the science shows do affect teachers' classroom practice. The majority of participants considered the science shows to be a good and valuable program. There was an indication that the programs affect the teaching practice positively.

The literature shows students' interest in studying science declines once it is no longer compulsory in schools. The literature also demonstrates the similarity of science teaching and learning practice in Australia and in Indonesia. Often teachers use chalk and talk teaching practices which do not focus on the needs of students. Students who cannot see the relevance of science to their everyday lives finally lose interest in studying science. The literature explains that informal learning complements formal science learning in interesting and fun ways.

A large proportion of the participants in this study provided positive comments about the shows. The majority of participants also agreed that the science shows had longer-term outcomes for students. Half of the participants claimed that their teaching practice had been influenced in some way.

A number of reasons supported the idea that the science circus programs would be feasible in Indonesia. Similar to Australia, Indonesia has a large area with a dispersed population. The science circus would improve the accessibility of the programs, bringing fun and excitement to the students and increasing the teachers' confidence teaching science subjects. All of the benefits that this evaluation has shown that the science circus brings to the schools are things that Indonesia needs. However, realising this is not easy and will require extensive coordination from all sectors, especially from government. Further investigation is needed before the science circus program could be implemented in Indonesia.

5.5.2 Limitations

Some limitations have been identified in this study and several recommendations are provided in order to improve further studies.

First, this study only investigated a particular science circus trip, from 26 February – 24 March 2005 to northern New South Wales. The schools visited in this trip may not be representative of all Australian schools because only a specific area of New South Wales was visited. Therefore, it was not possible to conclude that the study represents all Australian schools. This limited study also does not represent the whole performance of the science circus because it only evaluated one trip. The results of this study can be used as an indicator only.

Second, the particular trip observed was the first trip for the Graduate Diploma students. Thus, it may not represent their best performance of the year.

Third, the analysis of the impact of science shows on the teaching practices of teachers is based only on their own perspective. The study has not evaluated perspectives of students or any other parties.

Fourth, the main limitation of the self-administered questionnaire that was used for this study was a low response rate. In order to maximise the response rate, a small reward of science books was offered. A reminder letter was sent and the closing date was extended in an attempt to increase the response rate.

Finally, ethical and methodological limitations: only questionnaires were used to gather data. Although the questionnaire was designed to minimise bias, bias interpretation might be occur still because further clarifications with respondents were not possible due to ethical considerations.

5.5.3 Recommendations

At the time I conducted this study, one particular trip of the science circus was evaluated. For future research, a larger scale evaluation is desirable. Evaluation from several trips to different regions will provide a more comprehensive picture about Australian schools and their teaching and learning practice in science. The results could also be used to measure the science circus more thoroughly. Triangulation of data through the use of more varied methods is also desirable. For example, a questionnaire should be provided for students to complete, interviews could be conducted with both teachers and students, and a more extensive observation of the shows should be carried out.

I conducted this study based on teachers' perspective by questionnaire. Should further research to be conducted, an invitation to be interviewed should be included. Thus, further confirmation can be obtained from participants who agree to do so.

From the results of this study, it seems that teachers valued the science shows performed by the science circus positively. Data from this study show that a visit from the science circus had positive impacts on science teaching and learning practice. I also found that the Professional Development teachers' workshop conducted by the science circus had an important role in teaching practice for some teachers who took part in it. A further study should be conducted to confirm the value of the teachers' workshop.

This study also concludes that the science circus format is feasible in Indonesia. I am aware, of course, that there is still a great deal to do and further researching is necessary. To begin, I suggest *PPIPTEK* in Indonesia designs several science shows. For prototyping, the shows can be performed in some schools in rural areas of Java (the main island in Indonesia). Should the shows be well received by students and teachers in schools, a proposal to discuss this further with government is necessary.

This thesis might not offer an instant solution for science education problems in Indonesia. Science teaching and learning are not magic; they require time to progress. However, if we do not try we will never know whether it will work or not. So, shall we try?

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Appendices

Australian Government
Department of Education, Science and Training

Shell Questacon Science Circus

ADVANCE NOTICE:

Australia's only national travelling science centre is coming to your region in 2005!

Make a note in your 2005 planning diary today!

Dear Principal

cc. Deputy Principal, Science/Performing Arts Coordinator, Grade Teachers

Switch your students on to Science and Technology!

The ***Shell Questacon Science Circus*** performs exciting demonstration-style **science shows in schools** (bookings required) and brings a mobile Science Centre with more than 50 interactive exhibits to regional towns. This outstanding hands-on exhibition opens to the public outside school hours on some evenings and weekends. (No bookings). The *Science Circus* travels to all Australian states, visiting regional and rural centres an on a 3-6 year cycle.

In 2005, the *Shell Questacon Science Circus* can visit schools within 1.5 hours of the towns listed here:

Northern NSW	**March 2005**	Armidale, Casino, Glen Innes, Gunnedah, Inverell, Moree, Narrabri, Tamworth, Tenterfield, Walgett.
Northern Qld	**May 2005**	Barcaldine, Charters Towers, Cloncurry, Hughenden, Longreach, Mt Isa, Townsville, Winton.
Pilbara WA	**Aug/Sept 2005**	Carnarvon, Denham, Exmouth, Geraldton, Karratha-Dampier, Meekatharra, Newman, Port Hedland, Tom Price.
Eastern Vic	**Oct/Nov 2005**	Bairnsdale, Geelong, Moe, Morwell, Sale, Seymour, Traralgon, Warragul.

NB The itinerary listed here is correct at time of printing. Adjustments may be necessary depending on availability of venues/accommodation.

Cost and Grade Suitability: $4* per student covers a one-hour session of science shows and busks in your school plus a free student ticket to the mobile Science Centre set up in a public venue in some regional towns. The program includes shows for all grades, particularly grades Kindy to Year 8.

* GST free

Are you interested in a dynamic *Science Circus* performance at your school in 2005?

Please complete the 'Expression of Interest' data sheet overleaf. Return by free fax, or post a copy to:

SQSC 2005 Tours, PO Box 5322, Kingston ACT 2604

Note: this not a booking form and does not commit you to a visit.

We will follow-up your expression of interest with a booking information pack to arrive by post (addressed to the Contact Teacher nominated on the form) early in Term 4 2004.

Interactive, entertaining, educational…and in your school at an affordable price… that's the *Shell Questacon Science Circus!*

Like to know more?
Visit our award-winning web site:
http://www.questacon.edu.au/html/circus_for_teachers_.html

Financial Review Magazine Corporate Partnerships Award 2004

The Shell Company of Australia in partnership with Questacon and the Australian National University won this award for an Outstanding Long-Term Partnership in respect of the Shell Questacon Science Circus sponsorship.

Appendix B: Expression of interest

Expression of Interest in *Shell Questacon Science Circus* 2005 Tours

THIS IS *NOT* A BOOKING FORM! Registering your expression of interest in the *Shell Questacon Science Circus* 2004 Tours does not commit you to anything, but will enable us to **post the booking information addressed directly to you** for your consideration. 2005 School bookings are accepted from October 2004.

Please print clearly in upper case using black or red pen (blue does not fax well)

FULL SCHOOL NAME ______________________________

POSTAL ADDRESS ______________________________

State/Territory __________ Post Code ________

Tel: Area code ( ) ______________________ Fax: ( ) __________

E-mail______________________________

Principal ______________________________

Contact Teacher/Position______________________________
(Science Coordinator/Performing Arts Coordinator/Grade Teacher/School Administrator)

Number of students enrolled at your school ____________ Year levels ____________

In 2005, the *Shell Questacon Science Circus* can visit schools within 1.5 hours of the towns listed here. Please circle your closest regional town.

Northern NSW	**March 2005**	Armidale, Casino, Glenn Innes, Gunnedah, Inverell, Moree, Narrabri, Tamworth, Tenterfield, Walgett.
Northern Qld	**May 2005**	Barcaldine, Charters Towers, Cloncurry, Hughenden, Longreach, Mt Isa, Townsville, Winton.
Pilbara WA	**Aug/Sept 2005**	Carnarvon, Denham, Exmouth, Geraldton, Karratha-Dampier, Meekatharra, Newman, Port Hedland, Tom Price.
Eastern Vic	**Oct/Nov 2005**	Bairnsdale, Geelong, Moe, Morwell, Sale, Seymour, Traralgon, Warragul.

If your school is ***not*** located in the town you circled above, please provide an estimate of the travel time by car from this town to your school __________ (Presenters drive up to 1.5 hours from a 'base' town)

Are you interested in having a *Science Circus* performance at your school? ($4/student) **Yes/Maybe/No**

If you respond yes or maybe, we will send a booking pack by mail in a Questacon window-faced DL envelope **addressed directly to the contact person named above** early in Term 4 2004.

If your school is not interested in receiving further information would you please let us know why?

____

Is there anybody else in your district you think would be keen to hear about our visit?

____

Comments______________________________

Please return by Free Fax 1800 641 171 (no cover sheet required)

Appendix C: Booking information

Shell Questacon Science Circus
PO Box 5322
Kingston ACT 2604

www.questacon.edu.au

Free Phone 1800 889 995
Free Fax 1800 641 171

ABN: 71 460 521 691

The *Shell Questacon Science Circus* is coming to the New England region NSW in Term 1 2005 bringing science shows to schools, teacher workshops and an exhibition to regional towns!

Dear Principal and Teachers

The *Shell Questacon Science Circus* is the major outreach program from Questacon – The National Science & Technology Centre in Canberra. This excellent program travels throughout regional and remote Australia on a three to five year cycle. The cost is partially subsidised by DEST and an award-winning long term sponsorship from Shell.

In Term 1 2005, our team of 16 science presenters will travel throughout the New England region of NSW staying in the following regional centres: Armidale, Casino, Glen Innes, Gunnedah, Inverell, Moree, Narrabri, Tamworth, Tenterfield, and Walgett. Along the way we are offering:

- **IN–SCHOOL DEMONSTRATION-STYLE PERFORMANCES** **Bookings required**.
  ($4/student for one-hour show, includes free student entry ticket to the hands-on Public Exhibition)
- **S&T WORKSHOP FOR PRIMARY TEACHERS** **Bookings required.**
  ($25/teacher for a practical 2 hour workshop offered after school.)
- **PUBLIC EXHIBITION** A community event with tickets available at the door. **No bookings.**
  ($16/family or $5/adult, $4/student or concession, children under 5 free)

To arrange a school visit, fill in and return the pink booking application sheet enclosed with this letter. For your convenience we provide a Free Fax for return. Receipt of your booking application will be acknowledged by fax.

The *Shell Questacon Science Circus* is looking forward to visiting NSW in 2005!

For booking information contact:
Questacon Outreach Bookings Office Free Phone: 1800 889 995, Free Fax: 1800 641 171

Megan Black
Shell Questacon Science Circus Bookings Officer
Desk phone 02 6270 2824; Email mblack@questacon.edu.au

More information about Questacon Outreach Programs can be found on our web pages:

http://www.questacon.edu.au/html/outreach_programs.html

Shell Questacon Science Circus

Booking information for in-school performances
TERM 1 2005

A SCIENCE CIRCUS PERFORMANCE IN YOUR SCHOOL

- Our presentations cover both familiar and unexpected examples of the relevance of science in everyday life. A *Science Circus* experience is designed to stimulate and challenge students to explore science & technology for themselves, and may form a basis for follow-up activities.
- A session is usually lasts for one hour; however we can adjust to fit a 50-minute timetable for high school or infant groups where appropriate. Each session includes two 20-minute science shows plus two shorter demonstrations/discussions. We can present one or more sessions at your school. Session times are scheduled to fit into your normal school timetable where possible. Please indicate your school's start, finish and break times on the booking sheet.
- Shows are suitable for all school grades, especially Kindy to Year 8 and tailored for the age, ability and experience of the audience.
- Our presenters use familiar everyday materials to perform two exciting shows from a range of topics including Balance, Balloons, Bubbles, Collisions, Flight, Friction, Liquid Nitrogen, Music, Pressure, Roundabout, Shark, Slime, and Structures. A brief description of show topics is provided on the reverse side of the pink booking application sheet enclosed, however we cannot guarantee which topics you will see.
- **Audience:** Up to 120 students per session. We accept small audience numbers from isolated schools if our schedule allows. Some small schools invite others in their cluster to enjoy a science/sports day.
- **We need**: - a room big enough for the audience - a table
  - a power point - nearby access to water
- **Cost**: $4.00 per student. This small charge covers the in-school performance. Plus each student and teacher receives a free entry ticket to visit the *Science Circus* exhibition in your regional town.

TOUR DETAILS FOR TERM 1 2005 to NSW

Our show presenters can visit schools in the following regional towns and will travel up to 90 mins by hire car (sealed roads only) to outlying schools in the surrounding region:

TENTERFIELD	Mon 28th Feb		
CASINO		Tues 1st Mar	Wed 2nd Mar
		Thurs 3rd Mar	Fri 4th Mar
GLEN INNES (split teams)	Mon 7th Mar		
INVERELL (split teams)	Mon 7th Mar	Tues 8th Mar	
ARMIDALE	Wed 9th Mar	Thurs 10th Mar	Fri 11th Mar
MOREE (Walgett)	Mon 14th Mar	Tues 15th Mar	
NARRABRI (split teams)	Tues 15th Mar	Wed 16th Mar	
GUNNEDAH (split teams)		Thurs 17th Mar	Fri 18th Mar
COONABARRABRAN (split teams)	Mon 21st Mar		
TAMWORTH	Mon 21st Mar	Tues 22nd Mar	Wed 23rd Mar

NB: The touring plan above may alter slightly with local bookings demand or changed availability of an Exhibition venue.

BOOKINGS ARE ESSENTIAL

Fill in and fax back the pink schools booking application sheet enclosed, or use the on-line booking form.

Shell **Questacon** Science Circus

SCHOOL BOOKING APPLICATION

NSW in Term 1 2005

Mon 28th Feb to Wed 23rd Mar

FULL SCHOOL NAME

SCHOOL STREET ADDRESS ______

Contact Teacher (Name, Position) ______

Best way to communicate (give ph, fax, or email) ______

SCHOOL START/FINISH/BREAK TIMES ______

➢ **IN-SCHOOL PERFORMANCES**: ($4* per student)

1. Please check the tour dates for regional centres on the booking information sheet that is on the reverse side of the cover letter.
2. Estimate the travelling time by car from your closest regional centre ______
3. Nominate your show venue (eg school hall, double classroom) ______
4. Nominate your order of preference for the day/date of your visit:

   Preferred Days: Monday ______ Tuesday ______ Wednesday ______ Thursday ______ Friday ______
   Dates:

5. Fill out the table below with your preferred **show time**, **year levels** and **student numbers** per group. Audience up to 120 students per one-hour session, depending on the capacity of your school's show venue.

Session	Show Time	Student Year Levels	Estimated Student Numbers
1			
2			
3			
4			

6. Are you a very small school and interested in hosting the *Science Circus* to perform to your Cluster? Please provide names of all schools that would join in the day. ______

➢ **Are you interested in a PRIMARY TEACHER PD WORKSHOP?** ($25 per teacher)
More information at **http://www.questacon.edu.au/html/stress-free_science.asp**

1. Number of teachers at your school wishing to attend ______
2. Would you like to host a PD workshop at your school? Yes/No
3. Preferred day/date ______

Please send back your completed form via Free Fax: 1800 641 171, or post a photocopy to: Shell Questacon Science Circus Tour 1 2005 to NSW, PO Box 5322, Kingston ACT 2604

***Please note that all Questacon programs are GST free**

A Brief Description Of Some Of The *Shell Questacon Science Circus* Show Topics

NB Show content is adjusted to suit the age, ability and experience of the audience. We cannot guarantee which show topics you will see.

Balancing the Improbable: Got your balance! Examine the importance of the balance point – finding the centre of mass, stability, shape, balancing or hanging, positioning the centre of mass for stability, wobble etc

The Balloon Show: Have some serious fun with balloons considering some scientific principles of volume and air pressure, density, resistance, friction, static electricity, elasticity, Bernoulli's Principle, Newton's 1st Law of Motion

The Bubble Show: Bubbles are always fun! Explore some of enthralling properties of detergent films – surface tension, elasticity, surface area, energy, shape and volume, evaporation, light and colours etc

The Collisions Show: Bump! Take a closer look at what actually happens when objects collide – elastic and inelastic collisions, conservation of energy, potential and kinetic energy, energy transfer, impact forces, grip, friction, spin

The Flight Show: We've all dreamed of flying! Consider some of the fascinating science behind aircraft technology – density, pressure, speed, lift, propulsion, drag, deflection, Bernoulli's Principle, Newton's 3rd Law etc

The Friction Show: Get a grip on science friction! Take a closer look at how friction works, its place in music, heat, and lubricants, and when it's important to increase or decrease the friction.

The BOC Liquid Nitrogen Show: Super chill out! We'll show you some of the amazing properties of matter at different energy states – molecular energy, volume and pressure, cold boil, effects of freezing on living and non-living material etc

The Music Show: Is that music or noise? Explore some good vibrations - sound waves, frequency and pitch, amplitude and loudness, amplification, speed and quality of sound through different materials, resonance etc

The Pressure Show: Feeling under pressure? Share the load whilst investigating the astounding relationship between force, pressure and area – pressure in fluids, atmospheric pressure, water pressure, ways to and effects of changing pressure etc

Science Roundabout: Feeling dizzy? Go for a spin through some surprising science of rotational and circular motion – axis of rotation, distribution of mass, inertia and stability of rotating objects, forces, angular momentum, precession etc

The Shark Show: Should we be scared of sharks? Do movies like 'Jaws' give the wrong impression about these creatures? Uncover the truth about shark attacks and find out about these amazing animals.

The Slime Show: Don't you just love it! Take a closer look at some intriguing properties of fluids – viscosity, effects of temperature on Newtonian fluids, shear forces and Non-Newtonian fluids, stir-thinning and stir-thickening fluids etc

The Structures Show: Safer, stronger, lighter! Consider some of the forces acting on structures and the astounding ways various materials and shapes respond – reinforcing rods, catenary arches, domes, corrugations, I-beams, cylinders etc

More detailed information on show content can be found on our web pages at:
http://www.questacon.edu.au/html/sqsc_teacher_notes.html

Appendix E: Approval from Human Research Ethics Committee

THE AUSTRALIAN NATIONAL UNIVERSITY

THE AUSTRALIAN NATIONAL UNIVERSITY

RESEARCH OFFICE

Ms Yolanda Shave
Secretary, Human Research Ethics Committee

CANBERRA ACT 0200 AUSTRALIA
TELEPHONE:(02) 6125 7945
FACSIMILE: (02) 6125 4807
EMAIL: Yolanda.Shave@anu.edu.au

3 March 2005

Ms Claudina Milawati
Toad Hall
Kingsley Street
Acton, Canberra
ACT 2601

Dear Ms Milawati,

Protocol 2005/8
The impact of the Shell Questacon Science Circus visits to schools on students learning based on teachers' perspective

On behalf of the Human Research Ethics Committee I am pleased to advise that the above protocol has been approved as per the attached *Outcome of Consideration of Protocol.*

For your information:

1. Under the NHMRC/AVCC *National Statement on Ethical Conduct in Research Involving Humans* we are required to follow up research that we have approved. Once a year (or sooner for short projects) we shall request a brief report on any ethical issues which may have arisen during your research and whether it proceeded according to the plan outlined in the above protocol.
2. Please notify the Committee of any changes to your protocol in the course of your research, and when you complete or cease working on this project.
3. The validity of this current approval is five years' maximum from the date shown on the attached *Outcome of Consideration of Protocol* form. For longer projects you are required to seek renewed approval from the Committee.

Yours sincerely,

Y Shave

Ms Yolanda Shave
Secretary, Human Research Ethics Committee

THE AUSTRALIAN NATIONAL UNIVERSITY

THE AUSTRALIAN NATIONAL UNIVERSITY

HUMAN RESEARCH ETHICS COMMITTEE

Outcome of Consideration of Protocol

Researcher: Ms Claudina Milawati
Contact details: Postgraduate Student, Centre for the Public Awareness of Science, Faculty of Science
Protocol No. 2005/8
Title: The impact of the Shell Questacon Science Circus visits to schools on students learning based on teachers' perspective
Date on application: 20 December 2004 **Date received in Research Office:** 20 December 2004

On behalf of the Human Research Ethics Committee,

I approve/do not approve the above protocol.

Approval is subject to the following conditions:

....

....

....

Reasons for non-approval: ....

....

....

....

Review due: ....

Chairperson: ....L Cram........................ **Date:** 3/3/05.......................

Prof Lawrence Cram

Appendix F: Letter of invitation

Letter of Invitation

Dear Teacher of Science,

Thank you for booking the Shell Questacon Science Circus to come to your school in March 2005.

I am an ANU Masters student who is currently undertaking an evaluation of the Shell Questacon Science Circus in order to improve the program to better suit your students' needs.

Enclosed are questionnaires **for teachers who accompanied students and watched the science show**. It is a one-page questionnaire and will require roughly 10 minutes to answer. Your feedback is very valuable and highly appreciated. It will also be appreciated if you could ask other teachers who watched the science show to complete a questionnaire. If you need more questionnaires, you may make additional copies if necessary.

Please kindly return the questionnaire by free fax number: **1800 641 171** by **13 May 2005**.

All schools who respond to the questionnaire will be included in a draw to win the book: '101 Cool Science Experiments'.

If you have any enquiries please contact me on 0411 695 939 or by email: u4146686@anu.edu.au.

I am looking forward to hearing from you soon. Thank you very much for your kind attention and help.

Yours faithfully,

Claudina Milawati
Masters student in Scientific Communication
Centre for Public Awareness of Science
Australian National University
Canberra, ACT 0200

Appendix G: Information sheet

Information Sheet

This research is being conducted as part of a Masters sub-thesis by Claudina Milawati (student) under the supervision of Associate Professor Sue Stocklmayer of the Centre for Public Awareness of Science at the Australian National University.

The project aims to analyse the impact of Shell Questacon Science Circus visits to schools, based on teachers' perspectives.

This project aims to assist in improvement of the Shell Questacon Science Circus to better suit the needs of students and teachers in schools.

Teachers who complete these questionnaires will not be identified. If you decide to participate in this research, your questionnaire should be returned to Questacon by free fax number: **1800 641 171**. The questionnaire needs no teacher's identification.

All questionnaires will be stored in a locked filing cabinet in the researcher's office at the Centre for Public Awareness of Science. This is a secure location as the researcher's office is locked at all times. The data will be entered on the researcher's computer at the office and the files will be protected by password so only the researcher has access to it. The data will only be used for research purposes and the sub-thesis report.

Participation in this study is entirely voluntary. By not returning the questionnaire by **13 May 2005** you will be considered as having no interest in participating in this study. You are under no obligation to participate and are free to withdraw at any time.

Contact details:

Associate Professor Sue Stocklmayer (Supervisor)
Ph: (02) 6125 8157
E-mail: sue.stocklmayer@anu.edu.au

Claudina Milawati (Researcher)
Ph: 0411 695 939
E-mail: u4146686@anu.edu.au

Human Research Ethics Committee
Address: Research Office, Chancelry, ACT 0200
Ph: (02) 6125 7945
Fax: (02) 6125 4807
E-mail: Human.Ethics.Officer@anu.edu.au

Appendix H: Questionnaire

Questionnaire

Which class level do you teach? ____ Which class level did you accompany in the Science Circus show? ______

Which show did you see? ____

Has your school booked the Shell Questacon Science Circus before? ☐ yes ☐ no ☐ I don't know

How did you / your school learn about the Shell Questacon Science Circus? (you may answer more than one)
☐ from the offering letter sent by Questacon ☐ publications in media: newspaper or radio
☐ word of mouth, e.g. from other teachers ☐ other, please mention : ____________________

Do you think that your students enjoyed the show?
☐ very enjoyable ☐ generally enjoyable ☐ some enjoyed it, others not ☐ generally did not enjoy it

Please make a comment about the show that you saw in your school ______________________
____

Would you book the Shell Questacon Science if it were available in the future? ☐ yes ☐ no

Do you think the visit had longer-term outcomes for students? ☐ yes ☐ no

Please explain: ____
____
____
____

Did you / will you do any follow up activities for students in class? (e.g. discussion, repeating the science show, explaining the science behind the show, asking students to write a report, using the post visit materials given by Shell Questacon Science Circus team, etc). ☐ yes ☐ no

Please explain: ____
____
____
____

Has your own teaching been influenced in any way after the Shell Questacon Science Circus visit? ☐ yes ☐ no

Please explain: ____
____
____

Do you have any general comment / suggestion to improve the show that you saw in school? ______________
____
____

Any other comments? ____
____
____

Thank you for your participations!

I understand that any results in this questionnaire will be used in a Masters sub-thesis for CPAS ANU and will be reported to Questacon to aid in improving the Science Circus visits to schools

Appendix I: Reminder letter

THE AUSTRALIAN NATIONAL UNIVERSITY

NATIONAL CENTRE FOR THE PUBLIC AWARENESS OF SCIENCE
PHYSICS LINK BUILDING 38A
AUSTRALIAN NATIONAL UNIVERSITY
CANBERRA ACT 0200

Telephone: +61 2 6125 0498
Facsimile: +61 2 6125 8991
Email: cpas@anu.edu.au
http://www.cpas.anu.edu.au

Dear Science Teacher,

This is just a brief reminder to ask you to complete and return the questionnaire you received a couple of weeks ago from the Australian National University and Questacon. Over the last two weeks, many teachers have returned the questionnaire, giving us invaluable information to improve the program of the Shell Questacon Science Circus.

If you have already returned the questionnaire, thank you very much for playing a vital role in this research. All teachers who accompanied students and watched the science show are encouraged to participate in this study. If you require a replacement questionnaire please contact Claudina Milawati at the address below and we will arrange for a questionnaire to be sent to you. Your participation in this study is entirely voluntary.

Please return the questionnaire to our free-fax number: **1800 641 171** by **1 June 2005**.

I look forward to hearing from you. Thank you very much for your kind attention and help.

Yours sincerely,

Claudina Milawati

Masters student in Scientific Communication
Centre for Public Awareness of Science
The Australian National University
Canberra, ACT 0200

Mobile: 0411 695 939

Email: u4146686@anu.edu.au